Operations Strategy

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Contents

1 Introduction

This book covers the area of Operations Strategy. This is defined in chapter 2 before formulation methods for operations strategy are discussed in chapter 3. Operations strategy is considered in many organisations as the implementation of an improvement approach such as lean operations. Chapters 4 to 8 cover various improvement approaches including lean, BPR, ERP, TQM and Agile Operations. Chapter 9 covers the area of projects which provide the organisational structure around which operation strategies are implemented. Chapter 10 covers the area of structural decisions which should be made in the context of the operations strategy that has been adopted. Structural decisions cover aspects of the organisation's physical resources such as process types, layout design, facility location, process technology, product and service design and job design. Chapter 11 covers the area of infrastructural decisions which again should be made in the context of the Operations strategy. These cover how structural elements should be managed such as Inventory Management, Capacity Management and Supply Chain Management.

2 Defining Operations Strategy

In order to provide a definition of Operations Strategy the concept of operations management and business strategy are first discussed.

2.1 What is Operations Management?

Operations Management is about the management of the processes that produce or deliver goods and services. Not every organisation will have a functional department called 'operations', but they will all undertake operations activities because every organisation produces goods and/or delivers services. The operations manager will have responsibility for managing resources involved in these processes

The role of operations management is to manage the transformation of an organisation's inputs into finished goods and services using processes. Processes are actually present in all of the areas (HRM, finance, marketing etc.) of the organisation.

The two main types of transforming resources are:

- Facilities, such as building, equipment and process technology.
- Staff, all the people involved in the operations process. In services the customer may well be involved as a transforming resource.

The three main types of transformed resource are:

- Materials, these can be transformed either physically (e.g. manufacturing), by location (e.g. transportation), by ownership (e.g. retail) or by storage (e.g. warehousing),
- Information, this can be transformed by property (e.g. accountants), by possession (e.g. market research), by storage (e.g. libraries), or by location (e.g. telecommunications),
- Customers, they can be transformed either physically (hairdresser), by storage (e.g. hotels), by location (e.g. airlines), by physiological state (e.g. hospitals), or by psychological state (e.g. entertainment).

2.2 The Role of Services in Operations Management

The rise to prominence of the service sector in the economies of developed countries is due to an increase in what are termed consumer services and producer services.

- Consumer services are services aimed at the final consumers and these have risen in line with people's increasing disposable income in developed countries.
- Producer services are used in the production and delivery of goods and services and constitute firms providing services such as consultancy advice, legal advice, IT support, transportation and maintenance facilities.

Services can be classified by their tangibility, while the way they are delivered can be classified by their simultaneity.

- Tangibility
  This is the most commonly used distinction between goods and services. Goods are tangible, they are a physical thing you can touch. A service is intangible and can be seen as a process that is activated on demand. In reality however both goods and services have both tangible and intangible elements and can be placed on a continuum ranging from low to high intangibility
- Simultaneity
  This relates to the characteristic that services are produced and consumed simultaneously. This means the service provider and customer will interact during the service delivery process. The amount of interaction is termed the degree of customer contact.

It should not be assumed that all employees in a service operation have to deal directly with a customer. This distinction in services is denoted by 'back office' tasks which add value to the inputs of the service operation and 'front office' tasks which deal with the customer both as an input and output of the operation.

2.3 What is Strategy?

Strategy can be defined as follows (Johnson et al., 2008)

> 'Strategy is the *direction* and *scope* of an organisation over the *long term*: ideally, which matches its *resources* to its changing *environment*, and in particular its *markets*, *customers* or *clients* so as to meet *stakeholder* expectations.'

Strategy can be seen to exist at 3 main levels of corporate, business and functional:

- Corporate level Strategy
  At the highest or corporate level the strategy provides long-range guidance for the whole organisation – What business should we be in?
- Business Level Strategy
  Here the concern is with the products and services that should be offered in the market defined at the corporate level – How do we compete in this business?
- Functional Level Strategy
  This is where the functions of the business (e.g. operations, marketing, finance) make long-range plans which support the competitive advantage being pursued by the business strategy- How does the function contribute to the business strategy?

2.4 What is Operations Strategy?

Operations strategy is the total pattern of decisions which shape the long-term capabilities of any type of operation and their contribution to overall strategy, through the reconciliation of market requirements with operations resources (Slack and Lewis, 2011).

From the previous definition operations strategy is concerned with the reconciliation of market requirements and operations resources. It does this by:

- Satisfying market requirements (measured by competitive factors) by setting appropriate performance objectives for operations
- Taking decisions on the deployment of operations resources which effect the performance objectives for operations

Using a market-based approach to operations strategy an organisation makes a decision regarding the markets and the customers within those markets that it intends to target. The organisation's market position is one in which its performance enables it to attract customers to its products or services in a more successful manner than its competitors. Competitive factors are how a product/service wins orders (for example price, quality and delivery speed). A resource-based view of operations strategy works from the inside-out of the firm, rather than the outside-in perspective of the market-based approach. Here there is an assessment of the operations decisions regarding:

- structural decisions - physical arrangement and configuration of resources. These are covered in chapter 10.
- infrastructural decisions - activities that take place within the operation's structure. These are covered in chapter 11.

The nature and complexity of formal and informal processes and tangible and intangible resources is central to the resource-based view of strategy; that is externally unobservable (within firm) factors are at least as important as observable industry market (between firm) factors in determining competitive advantage. It has been found that not all companies pursue strategy in accordance with a pure market-based approach and it has been found that competitiveness is not just a matter of simply improving performance along specific competitive dimensions in response to market needs, but incorporates the development of capabilities that provide specific operating advantages. Thus the resource-based view of strategy is that operations takes a more active role in providing long-term competitive advantage.

What makes the development of operation strategy particularly challenging is that not only should the market-based and resource-based views of strategy need to be considered at a point in time, but the changing characteristics of markets and the need to develop operations capabilities over time means a dynamic as well as a static view of strategy is required.

3 Operations Strategy Formulation

There are many alternative procedures for developing an operations strategy for a particular organisation. These will generally require an analysis of market requirements (marketing) and the operation's resource capabilities (operations). The procedure covered here is the Hill framework.

3.1 Hill framework for Operations Strategy Formulation

Hill (2005) provides an iterative framework that links together the corporate objectives; which provide the organisational direction, the marketing strategy; which defines how the organisation will compete in its chosen markets, and the operations strategy; which provides capability to compete in those markets.

The framework consists of five steps:

1. Define corporate objectives
2. Determine marketing strategies to meet these objectives
3. Assess how different products win orders against competitors
4. Establish the most appropriate mode to deliver these sets of products
5. Provide the infrastructure required to support operations

Step 1 Corporate Objectives

Step 1 involves establishing corporate objectives that provide a direction for the organisation and performance indicators that allow progress in achieving those objectives to be measured. The objectives will be dependent on the needs of external and internal stakeholders and so will include financial measures such as profit and growth rates as well as employee practices such as skills development and appropriate environmental policies.

Step 2 Marketing Strategy

This involves identifying target markets and how to compete in these markets.

Step 3 How Do Products Win Orders in the Market Place?

This is the crucial stage in Hill's methodology where any mismatches between the requirements of the organisation's strategy and the operations' capability are revealed. This step provides the link between corporate marketing proposals and the operations processes and infrastructure necessary to support them. This is achieved by translating the marketing strategy into a range of competitive factors (e.g. price, quality, delivery speed) on which the product or service wins orders. These external competitive factors provide the most important indicator as to the relative importance of the internal operations performance objectives. The five basic internal operation's performance objectives allow the organisation to measure its operation's performance in achieving its strategic goals. The performance objectives are Quality, Speed, Dependability, Flexibility and Cost.

At this stage it is necessary to clarify the nature of the markets that operations will serve by identifying the relative importance of the range of competitive factors on which the product or service wins orders. Hill distinguishes between the following types of competitive factors which relate to securing customer orders in the marketplace.

- order-winning factors – They are key reasons for customers purchasing the goods or services and raising the performance of the order-winning factor may secure more business
- qualifying factors – Performance of qualifying factors must be at a certain level to gain business from customers, but performance above this level will not necessarily gain further competitive advantage.

From the descriptions above it can be seen that it is therefore essential to meet both qualifying and order-winning criteria in order to be considered and then win customer orders.

Step 4 Delivery System Choice (Structural Decisions) and Step 5 Infrastructure choice (Infrastructural Decisions)

Steps 4 and 5 of Hill's methodology involves putting the processes and resources in place which provide the required performance as defined by the performance objectives. Hill categorises operations decision areas into delivery system choice, (structural decisions) and infrastructure choice (infrastructural decisions). Delivery system choice concerns aspects of the organisation's physical resources such as service delivery systems and capacity provision (chapter 10). Operations Infrastructural decisions describe the systems, policies and practices that determine how the structural elements covered in step 4 are managed (chapter 11).

4 Lean Operations

The term Lean was first used by John Krafcik in his article "Triumph of the Lean Production System" which appeared in 1988. This paper found that productivity and quality levels in car assembly plants was not determined by an assembly plant's location. However plants that operated with a "lean" production policy were able to manufacture a wide range of models, yet maintain high levels of quality and productivity. The message was further disseminated by the book "The Machine That Changed the World" (1991) by Womack & Roos. The term 'lean' approach aims to meet demand instantly, deliver perfect quality and eliminate waste in all its forms.

Three key elements of Lean Operations are eliminate waste, involve everyone and continuous improvement.

4.1. Eliminate Waste

Waste is considered as any activity which does not add value to the operation. Ohno (1988) classified 7 wastes, the priority should be to avoid these wastes, only then to cut:

- Overproduction – making too much too early
- Waiting – Need to keep a flow of material/customers
- Unnecessary Motions – ergonomics and layout
- Transporting – unnecessary movements/handling
- Processing – Too much capacity in one machine instead of a number of smaller ones
- Inventory – Raw material, work in progress and finished goods
- Defects – costs of defects tend to escalate the longer they remain undetected

The 7 service customer wastes can be the basis for an improvement programme (Bicheno, 2008):

- *Delay* on the part of customers waiting for service, for delivery, in queues, for response, not arriving as promised.
- *Duplication*. Having to re-enter data, repeat details on forms and answering queries from several sources within the same organisation.
- *Unnecessary movements*. Queuing several times, poor ergonomics in the service encounter.
- *Unclear communication* and the wastes of seeking clarification.
- *Incorrect inventory*. Out-of-stock, unable to get exactly what is required, substitute products or services.
- *Opportunity lost* to retain or win customers, failure to establish rapport, ignoring customers, unfriendliness, and rudeness.
- *Errors* in the service transaction, product defects in the product-service bundle, lost or damaged goods.

4.2 Involvement of Everyone

Some organisations view the lean approach as consisting almost exclusively of waste elimination. However effective waste elimination is best achieved through changes in staff behaviour. Lean aims to create a new culture in which all employees are encouraged to contribute to improvement efforts through generating ideas. In order to undertake this level of involvement the organisation will provide training to staff in a wide range of areas, including techniques such as statistical process control (SPC) and more general problem solving techniques.

4.3 Continuous Improvement (CI)

Continuous Improvement or Kaizen, the Japanese term, is a philosophy which believes that it is possible to get to the ideals of Lean by a continuous stream of improvements over time. Continuous Improvement is needed because customer's views are continually changing and standards are rising. Kaizen is about moving tacit knowledge to explicit knowledge

- Tacit – 'Know-How' based on years of experience but may not be written down
- Explicit – Written down in principles and procedures

CI enables ideas held tacitly to be explicitly incorporated by the organisation.

Principles for implementing a continuous improvement effort include:

- *Create a mind-set for improvement*. Do not accept that the present way of doing things is necessarily the best.
- *Try and try again*. Don't seek immediate perfection but move to your goal by small improvements, checking for mistakes as you progress.
- *THINK*. Get to the real cause of the problem - ask why? five times.
- *Work in Teams*. Use the ideas from a number of people to brainstorm new ways.
- *Recognise that improvement knows no limits*. Get in the habit of always looking for better ways of doing things.

Visual control is used to facilitate continuous improvement work. Visibility is achieved through what is called the five S's (seiri, seiton, seiso, seiketsu, shitsuke) which roughly translate as organisation, tidiness, cleanliness, maintenance and discipline. To achieve these factors visibility measures include Andon signs (coloured lights), control systems such as the Kanban and performance charts such as Statistical Process Control (SPC) charts.

4.4 Implementing Lean

As stated earlier the 'lean' approach aims to meet demand instantly, deliver perfect quality and eliminate waste in all its forms. One of the ways it does this is through replacing the traditional push production system with a pull production system sometimes called 'lean synchronisation'. Other techniques include setup reduction and total preventative maintenance

4.4.1 Push Production Systems

In a push production system a schedule pushes work on to machines which is then passed through to the next work centre. At each production stage a buffer stock is kept to ensure that if any production stage fails then the subsequent production stage will not be starved of material. The higher the buffer stocks kept at each stage of the line, the more disruption can occur without the production line being halted by lack of material.

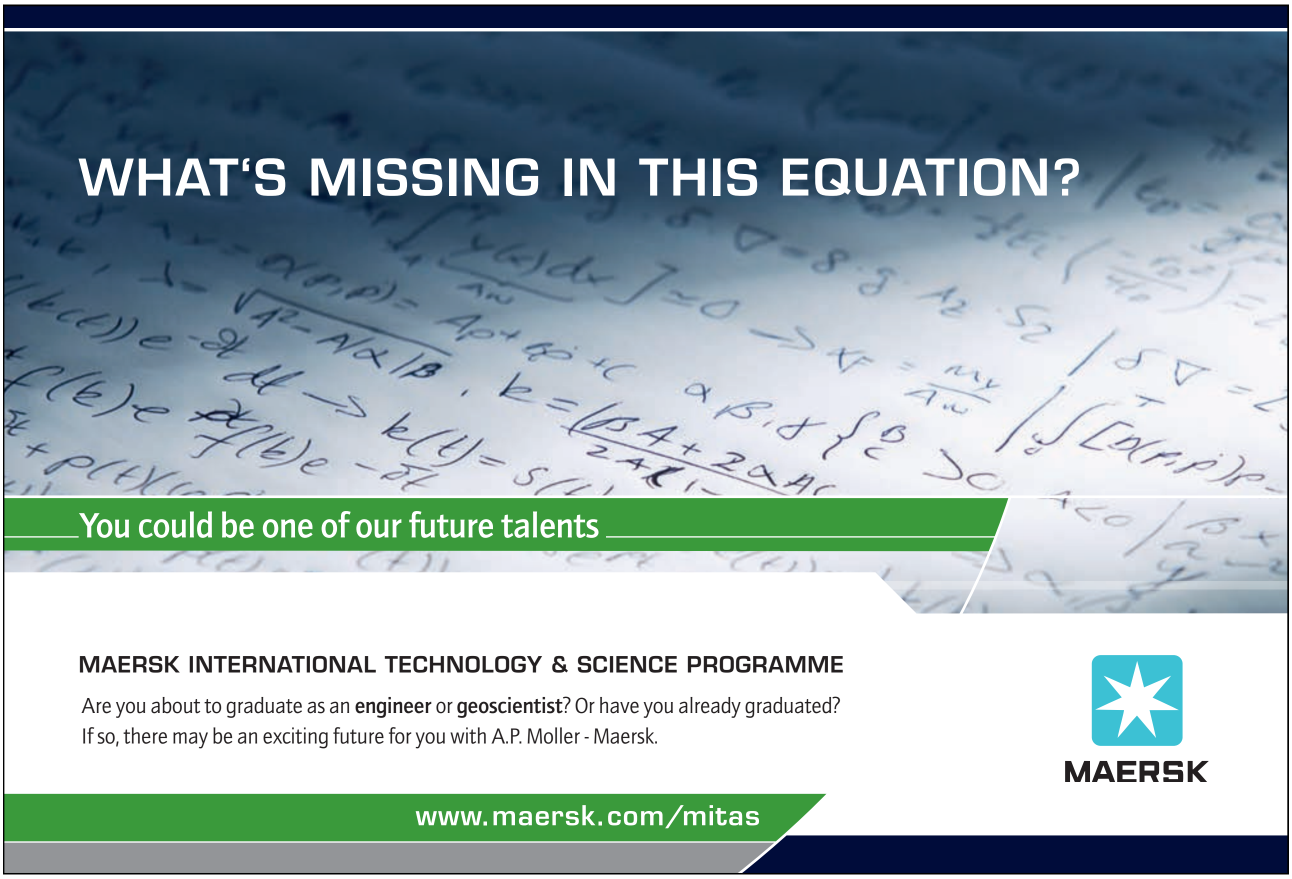
Advantages

- Buffers insulate stages against disruption in other stages

Disadvantages

- Because buffers insulate system from problems the problems are not visible so no one takes responsibility for fixing them.
- Buffer stock leads to high inventory and slower lead times
- Production is not connected to demand

In a pull system the process starts by an order for the finished product (e.g. car) at the end of the production line. This then triggers an order for components of that item which in turn triggers an order for further sub-components. The process repeats until the initial stage of production and the material flows through the system as in the 'push' approach.



Advantages

- No buffers so problems visible (whole line stops) so people take responsibility for fixing them.
- No or low buffer stock leads to low inventory and faster lead times
- Production is connected (pulled) to demand

Disadvantages

- No protection against unforeseen disruptions to supply chain

One system for implementing a pull system is called a kanban (Japanese for 'card' or 'sign') production system. Each kanban provides information on the part identification, quantity per container that the part is transported in and the preceding and next work station. Kanbans in themselves do not provide the schedule for production but without them production cannot take place as they authorise the production and movement of material through the pull system. Kanbans need not be a card, but something that can be used as a signal for production such as a marker, or coloured square area

4.4.2 Setup Reduction

In order to operate with the small batch sizes required by lean it is necessary to reduce setup time (the time taken to adjust equipment to work on a different component) drastically because of the increased number of setups needed with small batches. Originally some operations such as stamping car door panels with a press die were done in very large batch sizes, and the output stored in inventory, because the setup time for the press could be measured in hours or even days. Shigeo Shingo developed a system for setup reduction which became known as the Single Minute Exchange of Dies (SMED)

4.4.3 Total Preventative Maintenance (TPM)

This anticipates equipment failures through a programme of routine maintenance which will not only help to reduce breakdowns, but also to reduce downtime and lengthen the life of the equipment.

TPM includes the following activities:

- Regular Maintenance activities such as lubricating, painting, cleaning and inspection. These activities are normally carried out by the operator in order to prevent equipment deterioration.
- Periodic Inspection to assess the condition of equipment in order to avoid breakdowns. These inspections are normally carried out at regular time intervals by either operator or maintenance personnel.
- Preventative Repairs, due to deterioration, but before a breakdown has occurred. Normally carried out by maintenance personnel but ideally by the operators.

5 Business Process Reengineering (BPR)

Defined by Hammer and Champy (1993) as:

'the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed'

What does this definition mean……

- Fundamental rethinking – reengineering usually refers to the changing of significant business processes
- Radical redesign – involves a complete rethink about the way the business operates
- Dramatic improvements – tens or hundreds of percent improvement
- Critical contemporary measures of performance – process measures based on competitive factors of cost, quality, service and speed.

Hammer and Champy stress the use of information technology as a catalyst for these major changes. Examples given include decision support systems, teleconferencing and shared databases. BPR organises work around customer processes rather than functional hierarchies

Advantages of functional structures:

- Creates a pool of expertise which can service a number of areas
- Helps develop careers in a particular field

Disadvantages of functional structures:

- Focus of work can be on functional boss rather than end customer
- No one takes overall responsibility for overall process
- Tasks may be undertaken for internal functional reasons rather than overall business strategy

5.1 Implementing Business Process Redesign

The task of designing processes should be undertaken in a structured manner and the steps involved can be described as:

1. Identifying and documenting the process activities
2. Identifying processes for improvement
3. Evaluating process design alternatives

1. Identifying and documenting the process activities

The identification of activities in a current process design is a data collection exercise using methods such as examination of current documentation, interviews, and observation. In order to provide a framework for the design and improvement of service processes the techniques of process mapping and service blueprinting can be utilised.

2. Identifying processes for improvement

The identification of the relevant business processes for improvement can be undertaken using a scoring system in which prioritisation is governed by importance to customers and performance against competitors. Other measurement systems can be used such as a process marking guide covering the amount of impact and extent of innovation required of a process to meet performance across a number of critical success factors.

3. Evaluating Process Design Alternatives

There are many ways in which a process can be designed to meet particular objectives and so it is necessary to generate a range of innovative solutions for evaluation. Three approaches which can be used to generate new ideas are:

- Generating new designs through brainstorming
  This approach offers the greatest scope for radical improvements to the process design but represents a risk in the implementation of a totally new approach.

- Modifying Existing Designs
  This approach is less risky than a blue skies approach but may mean the opportunity for a radical improvement in process design is missed

- Using an established 'benchmark' design
  This approach applies the idea of identifying the best-in-class performer for the particular process in question and adopting that design.

Business Process Simulation (BPS) is used due its ability to incorporate the dynamic (i.e. time-dependent) behaviour of operations systems when evaluating alternative process designs. There are two aspects of dynamic systems which need to be addressed:

- Variability
  Most business systems contain variability in both the demand on the system (e.g. customer arrivals) and the durations (e.g. customer service times) of activities within the system.

- Interdependence
  Most systems contain a number of decision points that affect the overall performance of the system.

6 Enterprise Resource Planning (ERP)

ERP is an information system that aims to manage the large amounts of data in an organisation. ERP integrates sales, order, inventory, manufacturing and customer service activities. ERP systems provide software, databases, procedures and job descriptions for organisation wide processes. The characteristics of ERP are:

- Provides a cross-functional process view of the organisation.
- ERP applications include a set of inherent processes for all organisational activities. These processes may be documented in the form of a diagram, sometimes called a process blueprint.
- Generally organisations must adapt their processes to the blueprint, although it may be possible to adapt ERP software to organisational procedures.
- ERP stores information in a centralised database.

The history of ERP is as follows:

1. Materials Requirements Planning (MRP) (1970's)
   A method of translating a statement of required output into a plan for all activities that must take place to achieve the required output in the operations function.
2. Manufacturing Resource Planning (MRP 2) (1980's)
   Extends MRP across related departments; operations, marketing, finance and engineering
3. ERP (1990's)
   Integrates across all parts of the organisation; operations, finance, HRM, IT etc.
4. Web Integrated ERP (2000's)
   Integrates ERP using the web platform with other business systems

6.1 Manufacturing Requirements Planning (MRP)

MRP can calculate the requirements for component materials needed to produce end items. These components have what is called dependent demand. A dependent demand item has a demand which is relatively predictable because it is dependent on other factors. The components of an MRP system are the:

- Master production schedule (MPS)
- Bill of Materials (BOM)
- Inventory Status File (ISF)

6.1.1 Master Production Schedule (MPS)

The master schedule provides a plan for the quantity and timing of when orders are required. The MRP system will use this information and taking into account delivery, production and supply lead times and will indicate when materials are needed to achieve the master schedule. The MPS will usually show plans based on time 'buckets' based on for example a day or a week. The MPS will usually contain a mix of both plans for customer ordered items and plans to produce to forecast sales.

6.1.2 Bill of Materials (BOM)

The Bill of Materials (BOM) identifies all the components required to produce a scheduled quantity of an assembly and the structure of how these components fit together to make that assembly. The BOM can be viewed as a product structure tree, similar to an organisation chart. The accuracy of the BOM is vital in generating the correct schedule of parts at the right time.

6.1.3 Inventory Status File (ISF)

The Bill of Materials (BOM) indicates the quantity of components needed from the product structure, but this will not be directly translated into demand for components because it is likely that some of the components will be currently held in inventory. The inventory status file (ISF) provides information on the identification and quantity of items in stock. The MRP system will determine if a sufficient quantity of an item is in stock or an order must be placed. The inventory status file will also contain the lead time, or time between order and availability, for each component.

6.1.4 MRP Calculations

The following calculations are made by the MRP program.

- *Gross Requirements*. This is the estimated requirements for the item described.
- *Scheduled Receipts*. This indicates when the item becomes available for use, from a previously released order.
- *Projected On Hand*. This is the number of units to be available at the end of each time bucket based on the balance of requirements and receipts.
- *Net Requirements*. If the projected on hand is negative it is called a net requirement and means there will not be enough of this component to produce the quantities required to meet the master production schedule.
- *Planned Order Release*. The planned order release (POR) row indicates when an order should be released to ensure that the projected-on-hand figure does not become negative.

6.1.5 MRP Reports

A number of reports can be generated by the MRP program which include information on the quantity of each item to order in the current and future time period, indication of which due dates cannot be met and showing when they can be met and showing changes to quantities of currently ordered items. The system can also show the results of simulation of scenarios for planning purposes.

6.1.6 Limitations of MRP

The success of the system depends on the accuracy of the data but lead times and capacities are just static estimates and do not reflect dynamic nature of the operations system. Process times are variable so difficult to predict when work will arrive at a particular location so lead times are variable and depend on the utilisation of upstream resources. Therefore if lead time calculations are wrong then planning system cannot allocate capacity correctly.

6.2 Manufacturing Resource Planning (MRP II)

Manufacturing Resource Planning (MRP II) extends the idea of MRP to other areas in the firm such as marketing and finance. Thus central databases hold information on product structure (i.e. the Bill of Materials (BOM) file) which can be updated due to design changes by engineering for example. By incorporating financial elements into item details, inventory cost information can be utilised by finance departments. At a wider level information provided by the MRP II system from simulations of business plans can be used to estimate plant investment needs and workforce requirements. This information can then be used to co-ordinate efforts across departments including marketing, financing, engineering and manufacturing.

6.3 ERP

ERP extends MRP and MRPII across the organisation and takes a process perspective, so how does ERP improve process performance? An example is given of the procurement process which involves acquiring all the resources needed by an organisation in the form of purchases, rentals, contracts etc.

6.3.1 Manual Procurement Process

1 Create Order
  Physically check for stock levels
  Gather forms with previous purchases and potential suppliers

2 Get Quotes
  Prepare forms requesting availability and pricing information
  Collate quotation letters

3 Approve Order
  Transfer requisition information to purchase orders and send to selected suppliers

4 Receive Products and Services
  Match purchase order to delivery list when delivered
  Generate goods receipt form

5 Make Payment
  Match invoice from supplier with purchase order and goods receipt document
  Authorise and send payment

6.3.2 ERP Procurement Process

ERP supports the procurement process by:

1. Supporting the execution of the process
   Documents can be quickly and easily created and stored in the system

2. Capture and store data
   For example all stock levels and supplier information displayed on purchase requisition screen
   All forms (goods receipt, purchase order, invoice) held on database for checking

3. Help monitor performance
   Automatically generate exception reports if problems occur
   Provides a variety of reports in response to queries

6.3.3 Implementing ERP

ERP ensures all processes work to a template so potentially increasing efficiency. A centralised database increases data visibility and so improves communication and helps decision making. However working to the standard process design could mean some loss of flexibility.

6.4 Web-integrated ERP

This involves using the web to integrate ERP systems with outside stakeholders such as customers and suppliers. Many ERP systems have been found to offer only limited integration with Internet systems. The ideal is to integrate ERP with the internal systems of other businesses (not just connecting ERP to other customer and suppliers). This is difficult but these web-integrated ERP (also called c-commerce) applications are beginning to make an impact

7 Quality

Garvin (1988) provides 5 different perspectives on a definition of quality:

- Transcendent – The 'best' available – Rolls Royce
- Product Based – measurable attributes – car acceleration, speed etc.
- User Based – individual requirements – offer lots of options
- Operations Based – conforms to internal specification – no defects
- Value Based – 'value for money' – meets needs for lowest price

7.1 Defining Product Quality

How do customers define product quality? Garvin (1984) defines eight dimensions of quality or quality characteristics which the customer looks for in a product:

- Performance
- Features
- Reliability
- Conformance
- Durability
- Serviceability
- Aesthetics
- Other perceptions

The customer will trade-off these quality characteristics against the cost of the product in order to get a value for money product. This implies no one way to superior product quality.

7.2 Defining Service Quality

How do customers define service quality? Parasuraman, Zeithaml and Berry (1985) define quality in services along 5 dimensions:

- Reliability – delivered OK every time
- Responsiveness – delivery quick service and respond quickly to problems
- Assurance – employees delivering service should show competence
- Empathy – employees demonstrate an effort to understand customer needs
- Tangibles – physical surroundings must be appropriate

The customers use these 5 dimensions to form their judgement of service quality, which are based on a comparison of expectations and perceptions of that service quality; the difference is the service quality gap. The Service Gap Model can be used to help identify the gap between what customers expect from a service and what they perceive they are actually getting.

- Gap 1 – Operations concept –> Customer expectations
- Gap 2 – Operations concept -> product/service specification
- Gap 3 – Customer experience -> product service specification
- Gap 4 – customer experience -> communicated image
- Gap 5 – customer experience -> customer expectation; this is a consequence of gaps 1-4. either the concept is wrong (1), the concept is not turned into an appropriate specification (2), the specification is not properly executed(3), or the image communicated is not met(4).

7.3 Total Quality Management (TQM)

Total Quality Management (TQM) is a philosophy and approach which aims to ensure that high quality, as defined by the customer, is a primary concern throughout the organisation and all parts of the organisation work towards this goal. TQM does not prescribe a number of steps that must be followed in order to achieve high quality but rather should be considered a framework within which organisations can work. The TQM process will be dependent on factors such as customer needs, employee skills and the current state of quality management within the organisation.

TQM is a philosophy that stresses:

1. The customer defines quality and thus, their needs must be met.
2. Quality is the responsibility of all employees in all parts of the organisation
3. Identify and minimise all costs of quality
4. A continuous improvement culture must be developed to instil a culture which recognises the importance of quality to performance
5. A use of systems and procedures for improvement

1. The customer defines quality

This implies a need to discover customer needs and then focus quality improvement on meeting them. So the customer should be the focus of decision making, but operations managers should still assess what is feasible for the organisation to do.

2. Quality is the responsibility of all employees in all parts of the organisation

All staff, whether directly involved in production/ customer contact, or not can set in motion a chain of events which customers will eventually see as poor quality products or services. Staff are required not only to avoid mistakes, but think positively about improving how they perform their jobs. Service Levels Agreements (SLA) provide a formal definition of service between internal areas of the organisation

3. Identify and minimise all costs of quality

Quality gurus argue that the cost of poor quality and thus the benefits of improvement in quality should be identified, so quality costs can be classified:

The cost of achieving good quality:

- Prevention; trying to prevent problems – design of processes and products
- Appraisal; checking to see if problems have occurred during or after the creation of the product/service- testing, inspection

The cost of poor quality:

- internal failure; costs which are dealt with inside the operation – scrap, rework
- external failure; costs going out of the operation to the customer – returns, loss of goodwill

Traditionally it was assumed that an optimum level of spend can be identified because failure costs decrease as appraisal and prevention expenditure increases. This model was criticised because it assumes failure (poor quality) is acceptable, it assumes that costs are known and measurable and it implies that prevention is inevitably costly. The zero defect cost of quality model assumes it costs no more to remove the last error than the first (it might take longer to find the source of the error though), it needs proactive involvement of people in order to identify the causes of errors and the optimum number of defects is zero.

4. A continuous improvement culture must be developed

TQM espouses the process of continuous improvement (CI).

5. A use of systems and procedures for improvement

A key aspect of TQM is developing the procedures which support improvement. ISO 9000 provides a quality standard between suppliers and a customer developed by the International Organisation for Standardisation. Having a predefined quality standard reduces the complexity of managing a number of different quality standards when a customer has many suppliers. The standard is general enough to apply to almost any good or service, but it is the specific organisation or facility that is registered or certified to the standard. Other programmes which attempt to provide national and international standards for quality are the European Quality Award (EQA) and the Deming Prize.

7.4 TQM techniques

2 techniques associated with TQM and used to improve quality in operations are Statistical Process Control (SPC) and Six Sigma.

7.4.1 Statistical Process Control (SPC)

Statistical Process Control (SPC) is a sampling technique which checks the quality of an item which is engaged in a process. SPC should be seen as a quality check for process rather than product design. Quality should be built in to the product during the design stage. SPC works by identifying the nature of variations in a process, which are classified as being caused by 'chance' causes or 'assignable' causes.

- Chance Causes of Variation
  All processes will have some inherent variability due to factors such as ambient temperature, wear of moving parts or slight variations in the composition of the material that is being processed. The technique of SPC involves calculating the limits of these chance-cause variations for a stable system, so any problems with the process can be identified quickly.

- Assignable Causes of Variation
  If an 'out-of-control' process is discovered, then it is assumed to have been caused by an assignable cause of variation. This is a variation in the process which is not due to random variation but can be attributed to some change in the process, which needs to be investigated and rectified.

The limits of the chance-cause variations are called control limits and are shown on a control chart, which also shows sample data of the measured characteristic over time. There are control limits above and below the target value for the measurement, termed the upper control limit (UCL) and lower control limit (LCL) respectively.

7.4.2 Six Sigma

Six Sigma is a quality improvement initiative to achieve quality levels which are within 6 sigma control limits, corresponding to a rate of 3.4 defective parts per million (PPM). Thus 6 sigma can be defined as the process of comparing process outputs against customer requirements. However 6-sigma has developed from this examination of process variation to become a companywide initiative to reduce costs through process efficiency and increase revenues through process effectiveness. 6 sigma has an emphasis on training – level of expertise is denoted by black belt, green belt etc. Six Sigma contains plans for both increasing effectiveness and efficiency leading to so increased revenues and thus improving company performance.

- Improving Effectiveness
  The level of effectiveness of the organisation is reflected in the level of customer satisfaction. This means that efforts to improve effectiveness will focus on identifying and meeting internal and external customer requirements.

- Improving Efficiency
  The aim of every process improvement approach using Six Sigma is to achieve measurable cost savings through a focus on decreasing process variation.

7.4.3 The DMAIC Methodology

6 sigma incorporates a structured approach to improvement called DMAIC. This is a five step methodology of define, measure, analyse, improve and control and is used to both improve process performance and to improve process or product design. It is a cyclical approach like the PDCA cycle.

- *Define* – Identify a potential area of improvement and define the project scope.
- *Measure* – Decide what characteristics of the process require improvement.
- *Analyse* – Use the data collected in the measure phase to document current performance.
- *Improve* – Eliminate the root causes of non-random variation to achieve improvements in predictability, dispersion and centring.
- *Control* – Verify and embed the change through the use of techniques such as control charts.

8 Agile Operations

Agile Operations aim to respond quickly to market demand in order to retain current markets and gain new market share. As a strategy agile operations can be seen to embrace uncertainty in markets and achieve competitive advantage by the flexibility and speed of their response to them. The focus of agility has moved from an individual organisation to supply chains in which several companies work together. A supply chain is a series of activities that moves materials from suppliers, through operations to customers.

The traditional way to deal with uncertainty of demand is to improve forecast quality. However difficult to do in volatile markets, so emphasis is on reducing 3 critical lead times:

1. Time-to-market –how long does it take to recognise a market opportunity and bring products/services to market
2. Time-to-serve –how long does it take to capture a customer's order and to deliver the product
3. Time-to-react – how long does it take to adjust the output of the business in response to volatile demand

Companies are slow to recognise changes in demand in the marketplace because of a lack of visibility. Supply chains are driven by orders which are in turn driven by independent forecasts and inventory replenishment decisions by organisations along the supply chain from retailers to wholesalers to manufacturers. Thus upstream parties are unable to anticipate changes in the needs of customers

- Lead Time Gap = Logistics Pipeline – Customers Order Cycle Time
- Logistics Pipeline = Time to source materials, convert them into products and move them to the marketplace
- Customers Order Cycle Time = How long customer is prepared to wait for product

To overcome lead time gap, traditional way is to make to forecast inventory

8.1 Agile Supply Chains

Agile supply chains aim to be shorter and demand driven in order to overcome lead time gap. Agile supply chains should offer the following benefits:

- Visibility
  Supply chain participants should have full visibility of customer demand, supply sources, inventory levels, promotion plans etc. This visibility should help companies increase the speed of the flow of materials, information and customers through their organisation and thus speed up response times.

- Flexibility
  Key areas are product development, sourcing, manufacturing and logistics flexibility.

- Speed
  The end-to-end cycle time from manufacture to distribution. The smaller the cycle time the quicker responses can be implemented

- Predictability
  The response of the supply chain to changes should be predictable to all supply chain participants

- Scalability
  The ability to respond to demand changes

8.2 Lean Supply Chains

An alternative model to agile supply chain is the concept of the lean supply chain. Lean supply chains adopt the concept of lean operations across the supply chain. Lean supply chains emphasise efficiency.

Efficiency is achieved by policies such as minimising inventory across the supply chain and continuous improvement across the supply chain

8.3 Leagility – Combining Lean and Agile

It is suggested that there are three ways of bringing lean and agile together (Christopher and Towill, 2001)

1. Pareto Rule (80/20 rule)
- 80% of volume generated from 20% of product line
- Use lean for 20% of predictable high volume product lines. Seek economies of scale and make to forecast.
- Use agile for 80% of less predictable product lines. Aim for quick response and make to order.

2. Postponement
- This involves the use of a decoupling point which holds 'strategic' inventory in modular form until precise customer requirements are known.
- Companies can use lean methods up to the decoupling point and then agile methods beyond it.
- The concept can also be used with an information decoupling point. This represents the furthest point upstream at which 'real' demand information flows (i.e. information not distorted by policies such as re-order points).

3. Base and Surge
- Base demand can be forecast on the basis of history and so can be met using lean to maximise efficiency
- Surge demand is met by more flexible (agile) processes.
- One strategy is to source base demand in low cost countries and meet surge demand in local markets (albeit at higher cost but more effective overall).

8.4 Mass Customisation

Mass customisation can be seen as an example of the agile approach. Mass customisation describes the ability to produce and distribute what are perceived to be customised goods and services within a high volume or mass market (Davis, 1987). Mass customisation is based on the assumption that market requirements are becoming increasingly fragmented, while operations resources are allowing a greater degree of flexibility and responsiveness. Therefore it is possible to 'mass produce' a basic family of products or services which can still be customised to the needs of individual customers.

Vonderembse and White (2004) describe 3 levels of customisation:

- Customer-contact
  This is were a product or service is tailored to individual needs. E.g. haircut
- Adaptive
  A standard product is customised to individual needs through the use of options. e.g. car
- Presentation
  Standard products are presented differently to different customers. e.g. packaging

8.5 Quick Response Manufacturing (QRM)

A company-wide strategy for reducing lead times throughout the enterprise. External lead times are reduced by rapidly designing and manufacturing products to customer's needs. Internal lead times are reduced in order to improve quality, lower cost and provide quicker response to the customer

QRM is based on 4 core concepts (Suri, 2010):

1. The power of time
- The reduction of lead time should drive all decisions
- Lead time is defined as the typical amount of calendar time from when a customer creates an order, through the critical path until the first piece of that order is delivered to the customer.
- Reduced lead time = quick response

4 Organisation structure
- Move from functional departments to flexible cells
- Move from top-down control to team ownership
- Move from specialised, narrowly focused workers to a cross-trained workforce
- Move from efficiency/utilisation goals to lead time reduction

5 System Dynamics
- This looks at how interaction between machines, people, and products impact lead times.
- Do not have too high utilisation of resources as this can increase lead times considerably
- Reduce variability in flow time (arrival time + process time) to reduce lead time
- Choose a batch size that minimises lead time

6 Enterprise-wide application
- Apply the principle of minimising lead time across all departments
- Apply the principle of minimising lead time to suppliers
- Apply the principle of QRM to rapid new product development

9 Project Management

Projects are unique, one-time operations designed to accomplish a specific set of objectives in a limited time frame. Historically associated with either large construction type activities or the introduction of new products and processes. Under the mass production era (until the 1980's) product/process life cycles were relatively long aimed at mass markets so project development costs and time only a small proportion of product cost. However in recent years the ability to manage projects has become more important for operations managers.

Not all project problems are at the execution stage, but may relate to the process of identifying possible projects and making an appropriate selection of projects to execute. Problems include taking on too many projects for the resources available and not aligning individual projects with the organisation's strategy.

Projects ideas should be initiated from different organisational areas (operations, marketing, engineering etc.) and external sources such as customers, suppliers and competitors (e.g. benchmarking) to provide the greatest mix of ideas. The aim should be to pick the best portfolio of projects, not necessarily the best individual projects as their objectives and use of resources may conflict and there should be care taken against spreading the most skilled staff across too many projects. Project completion times are often unrealistic due to not taking into account capacity availability (usually people's time) and the number of other projects ongoing at any one time. Projects have different characteristics that require different approaches. Projects may range from small enhancements of current processes to major changes in process design or development of products for new markets. Experience project managers are required for breakthrough projects.

There should be a formal process for project selection so they are chosen on the basis of the overall strategy rather than for political reasons. Senior management should provide coordination between projects and make available suitable human resources. Management should abandon projects that are failing due to technical or market barriers, overlap with other projects or have failed to meet objectives.

9.1 Executing Projects

The following elements of project execution will be covered:

- Project definition and scoping
- Organisation of Project Teams
- Estimate, Planning and Control Activities

9.1.1 Project definition and scoping

Projects require a clear definition and boundary to determine what should be included and what should be outside the scope of the project. Scoping the project is very important when outsourcing as disputes can occur if the project does not have a clear definition. Definition may be made by detailed evaluation at the start of the project or evolved through a process of interaction with the customer during development.

9.1.2 Organisation of Project Teams

There are three main ways of structuring project teams within the organisation:

- **The Project Structure**
  This consist of an a organisation which not only follows a team approach to projects, but has an organisational *structure* based on teams formed specifically for projects. These are best suited when there is a need for a high degree of cross-functional co-operation.
- **The Functional Structure**
  Here a project is given to the most appropriate functional department. Thus the organisational structure remains in the standard hierarchical form. These are best suited when in-depth functional expertise is important.
- **The Matrix Structure**
  Here a series of project teams are overlaid on a functional structure in an effort to provide a balance between functional and project needs. These provide a compromise between the pure project and functional structures.

9.1.3 Estimate, Planning and Control Activities

Project estimating involves estimating the type and amount of resources required to undertake a project. Resource-constrained Project: If highly specialised resources are required then the project completion date may have to be set to ensure these resources are not overloaded. Time-constrained Project: If there is a need to complete a project in a specific time-frame alternative resources may have to be utilised to ensure timely project completion. The next step is to generate estimates for the time and resources required to undertake each task defined in the project. This information can then be used to plan what resources are required and what activities should be undertaken over the life cycle of the project. Once the activities have been identified and their resource requirements estimated it is necessary to define their relationship to one another. There are some activities that can only begin when other activities have been completed, termed a serial relationship. Other activities may be totally independent and thus they have a parallel relationship.

The purpose of the planning stage is to ensure that the project objectives of cost, time and quality are met. It does this by estimating both the level and timing of resources needed over the project duration. These steps may need to be undertaken repeatedly in a complex project due to uncertainties and to accommodate changes as the project progresses.

Project Control involves the monitoring of the project objectives of cost, time and quality as the project progresses. It is important to monitor and assess performance as the project progresses in order that the project does not deviate from plans to a large extent. Milestones or time events are defined during the project when performance against objectives can be measured.

9.2 Network Analysis

Network analysis refers to the use of network-based techniques for the analysis and management of projects. This section describes two network analysis techniques of the critical path method (CPM) and the programme evaluation and review technique (PERT). The main difference between the approaches is the ability of PERT to take into consideration uncertainty in activity durations.

9.2.1 Critical Path Method (CPM)

Critical path diagrams are used extensively to show the activities undertaken during a project and the dependencies between these activities. A completed network will consist of a number of nodes connected by lines, one for each task, between a start and end node. Once the network diagram has been constructed it is possible to follow a sequence of activities, called a path, through the network from start to end. The length of time it takes to follow the path is the sum of all the durations of activities on that path. The path with the longest duration gives the project completion time. This is called the critical path because any change in duration in any activities on this path will cause the whole project duration to either become shorter or longer.

The following four steps show how to identify the critical path.

- Calculate the Earliest Start/Finish times (forward pass)
- Calculate the Latest Start/Finish times (backward pass)
- Calculate the slack/float times
- Identify the Critical Path

There must be at least one critical path through the network, but there can be more than one. The significance of the critical path is that if any node on the path finishes later than the earliest finish time, the overall network time will increase by the same amount, putting the project behind schedule. Thus any planning and control activities should focus on ensuring tasks on the critical path remain within schedule.

The Gantt chart provides an overview for the Project Manager to allow them to monitor project progress against planned progress and so provides a valuable information source for project control.

Within any project there will be a number of time-cost trade-offs to consider. Most projects will have tasks which can be completed with an injection of additional resources, such as equipment or people. Reasons to reduce project completion time include:

- Reduce high indirect costs associated with equipment.
- Reduce new product development time to market
- Avoid penalties for late completion
- Gain incentives for early completion
- Release resources for other projects.

The use of additional resources to reduce project completion time is termed *crashing* the project.

9.2.2 Project Evaluation and Review Technique (PERT)

The PERT approach attempts to take into account the fact that most task durations are not fixed but vary when they are executed. Thus PERT provides a way of incorporating risk into project schedules. The probabilistic approach involves three time estimates for each activity of optimistic, pessimistic and 'most likely'.

9.2.3 Benefits and Limitations of the Network Analysis Approach

In terms of benefits the approach requires a structured analysis of the number and sequence of tasks contained within a project, so aiding understanding of resource requirements for project completion. It provides a number of useful graphical displays which assist understanding of such factors as project dependencies and resource loading. It gives a reasonable estimate of the project duration and the tasks which must be completed on time to meet this duration (i.e. the critical path). The network acts as a control mechanism to monitor actual progress against planned progress on the Gantt chart. It can be used to provide cost estimates for different project scenarios.

In terms of limitations PERT and simulation techniques may reduce time estimation errors, but at the cost of greater complexity which may divert management time away from more important issues. Time estimates for tasks may be greater than necessary to provide managers with slack to ensure they meet deadlines ('sandbagging') or too short for a realistic estimate ('blue skies'). The method assumes activities are independent. Actually the duration of one activity may be dependent on the duration of another. The method assumes a precise breaking point between activities. In reality one activity may start before a predecessor activity has finished. Activities just off the critical path may become critical after it is too late to do anything about them.

10 Structural Decisions

This chapter covers structural decision areas which need to be aligned with the operations strategy.

10.1 Process Types

Process Types are ways of describing the general approach taken to designing and managing processes. They are based on two important factors in process design: the volume and variety of the products and services that an organisation processes.

Most processes operate on a continuum from a combination of low volume/high variety through to a combination of high volume/low variety. This continuum can be represented by a graph of a diagonal line (termed the 'natural diagonal' by Hayes and Wheelwright, 1984) which represents the 'natural' line of fit. Most processes should lie close to this line which represents a fit between the process and its volume-variety position.

10.1.1 Manufacturing Process Types

In manufacturing, process types can be considered under five categories of project, jobbing, batch, mass and continuous.

- **Project**
  Processes that produce products of high variety and low volume are termed projects. Project processes are used to make a one-off product to a customer specification. A feature of a project that the location of the product is stationary.

- **Jobbing**
  Processes that produce products of high variety and low volume are termed jobbing. Jobbing processes are used to make a one-off (or low volume) product to a customer specification. A feature of a jobbing process is that the product moves to the location of transforming resources such as equipment.

- **Batch**
  Processes that produce products of medium variety and medium volume are termed batch. The size of a batch or group can range from one to hundreds. A feature of batch processes is that, because it is difficult to predict when a batch of work will arrive at a machine, a lack of coordination can lead to many products waiting for that machine at any one time.

- **Mass**
  Processes that produce products of high volume and low variety are termed line or mass processes. Although there may be variants within the product design the production process will essentially be the same for all the products. Because of the high volumes of product it is cost effective to use specialised labour and equipment.

- **Continuous**
  Processes that operate continually to produce a very high volume of a standard product are termed continuous. The products produced by a continuous operation are usually a continuous flow such as oil and gas. Continuous processes use a large amount of equipment specialised and dedicated to producing a single product.

10.1.2 Service Process Types

Three service process types, professional service, service shop and mass service are categorised in terms of their ability to cope with different volume and variety characteristics.

- **Professional Service**
  Professional Service processes operate with high variety and low volume. They are characterised by high levels of customisation, in that each service delivery will be tailored to meet individual customer needs. This customisation requires communication between the service provider and customer and so professional services are characterised by high levels of customer contact and a relatively high proportion of staff supplying the service in relation to customers. The emphasis in a professional service is on delivering a process rather than a tangible product associated with a process.

- **Service Shop**
  Service Shop processes operate with a medium amount of variety and volume. There will be a certain amount of customisation of the service, but not as extensive as in professional services. There will be therefore a mix of staff and equipment used to deliver the service. There is an emphasis both on the service delivery process itself and any tangible items that are associated with the service.

- **Mass Service**
  Mass Service processes operate with a low variety and high volume. There will be little customisation of the service to individual customer needs and limited contact between the customer and people providing the service. Because the service is standardised it is likely that equipment will be used to improve the efficiency of the service delivery process. The emphasis in a mass service is on the tangible item that is associated with the service delivery.

10.2 Layout Types

Layout Types are ways of describing the physical location or positioning of resources in processes. They are based, partly, on the volume and variety of the products and services that an organisation processes. Other factors include a need to minimise movement of material or people or to encourage communication between employees.

There are four basic layout types of fixed position, process, cell and product layout. There is often a choice of layout types for a particular process type (such as a process layout or cell layout for batch process types). In this case the choice will depend on the characteristics of the layout type that are particularly relevant for the product or service that is to be delivered. The characteristics of each of the layout types will now be considered.

- **Fixed Position Layout**
  This layout design is used when the product or service cannot be moved and so the transforming process must take place at the location of product creation or service delivery. In a fixed position layout all resources for producing the product, such as equipment and labour must move to the site of the product or service. The emphasis when using a fixed-position layout is on the scheduling and coordination of resources to ensure that they are available in the required amounts at the required time.

- **Process Layout**
  A process layout, also termed a functional layout, is one in which resources (such as equipment and people) which have similar processes or functions are grouped together. Process layouts are used when there is a large variety in the products or services being delivered and it may not be feasible to dedicate facilities to each individual product or service. A process layout allows the products or customers to move to each group of resources in turn, based on their individual requirements. Because of their flexibility process layouts are widely used. One advantage is that in service systems they allow a wide variety of routes that may be chosen by customers depending on their needs. Another advantage is that the product or service range may be extended and as long as no new resources are required may be accommodated within the current layout.

- **Cell Layout**
  A cell layout attempts to combine the efficiency of a product layout with the flexibility of a process layout. Cells are created from placing together resources which service a subset of the total range of products or services. When grouping products or services together in this way the grouping is termed a family. The process of grouping the products or services to create a family is termed group technology. Creating cells with dedicated resources can significantly reduce the time it takes for products and services to pass through the process by reducing queuing time. It also offers the opportunity for automation due to the close proximity of the process stages

- **Product Layout**
  Product layouts, also termed line layouts, arrange the resources required for a product or service around the needs of that product or service. In manufacturing applications such as assembly lines with a high volume of a standard product the products will move in a flow from one processing station to the next. The term product layout refers to the arrangement of the resources around the product or service. In services the requirements of a specific group of customers are identified and resources setup sequentially so the customers flow through the system, moving from one stage to another until the service is complete.

10.2.1 Detailed Layout Design

Once the layout type has been chosen its detailed configuration must be designed to meet the needs of a particular implementation. In a fixed-position layout there will be a relatively low number of elements and there are no widely used techniques to help locate resources. A process layout can be analysed in terms of minimising transportation costs or distances using an activity matrix. When a number of factors need to be taken onto account, including qualitative aspects, relationship charts may be used. Process maps can also be used to show the flow of materials, customers and staff through the layout.

10.3 Facility Location

The location decision can be considered in terms of factors that vary in such a way as to influence cost as location varies (supply-side factors) and factors that vary in such a way as to influence customer service as location varies (demand-side factors). The location decision can be seen as a trade-off between these factors. In service organisations a need for customer contact may mean that demand-side influences will dominate while in a manufacturing company labour and distribution costs may mean supply-side influences dominate.

10.3.1 Supply-Side Influences

When the location decision is considered in terms of factors that vary in such a way as to influence cost as location varies. These factors include:

- Distribution Costs – For example bulky products mean high distribution costs – textile plant
- Labour Costs – wage rates vary in different countries – call centres
- Energy Costs – can be a major cost factor in some industries
- Site and Construction Costs – suitability of land – may need treatment if polluted
- Intangible Factors – For example environmental issues

10.3.2 Demand-Side Influences

When the location decision is considered in terms of factors that vary in such a way as to influence customer service as location varies. These factors include:

- Labour Skills – Specialist skills only likely in certain areas – e.g. finance, IT
- Location Image – For example high-end retailers seek high status locations
- Customer Convenience – For example customers require restaurants relatively close to their location.

10.4 Process Technology

The objective of an operations system is to convert transformed resources from inputs into outputs in the form of goods and services. Process technology is the application of technology to transformed resources which can be in the form of:

1. material
2. information
3. customers

Note that some process technologies can process a combination of these (e.g. airport check-in). Process technologies can also be used for indirect processing such as for yield management and forecasting.

10.4.1 Process Technology for Materials

Software Systems:

- Computer Aided Design (CAD): A CAD system allows the designer to create drawings on a computer screen to assist in the visual design of a product or service.
- Computer Aided Process Planning (CAPP): This transmits a process plan of how parts will be manufactured to a machine tool. It can also sequence parts through a number of process steps. Uses group technology to process parts in families.
- Computer Aided Engineering (CAE): This takes the drawings in a CAD system and subjects the designs to simulated tests.

Hardware Technologies:

- Computer Aided Manufacturing (CAM): This extends the use of CAD by transmitting the design held in the CAD system electronically to computer controlled machine tools.
- Automated Material Handling Systems (AMH): These are designed to improve efficiency in the movement, storage and retrieval of materials. An example is an Automated Guided Vehicle (AGV).
- Flexible Manufacturing Cell (FMC): These are systems that integrate individual items of automation to form an automated manufacturing system.
- Flexible Manufacturing Systems (FMS): These extend the facilities of a FMC by incorporating automatic part loading and unloading facilities and an automated guided vehicle system for parts movement.
- Computer-Integrated Manufacture (CIM): This is the automation of the product and process design, planning and control and manufacture of the product.

10.4.2 Process Technology for Information

Most organisations use some form of computer-based technology to accumulate, organise and distribute information. In order to understand how the information technology is applied, it is useful to outline some of the types of information systems that use information technology in manufacturing and service organisations.

Operational Information Systems are used in the daily running of a business.

- *Transaction processing systems (TPS)*. These systems involve recording and processing data that results from an organisation's business transactions.
- *Office automation systems (OAS)*. OAS are used to manage the administrative functions in an office environment and are often critical to service-based industries.
- *Workflow Management Systems* (WFMS). These automate a business process.
- *Process control systems*. These include systems such as CAD, CAM and FMS which are important in manufacturing industries for controlling the manufacture of goods. (These process materials and information).

Management Information Systems are used to support tactical and strategic decision making.

- *Decision Support Systems (DSS)*. These provide information and models in a form to facilitate tactical and strategic decision making.
- *Information Reporting Systems (IRS)*. These provide pre-specified reports for day-to-day decision making.
- *Executive Information Systems (EIS)*. These provide senior managers with a system to analyse, compare and highlight trends to help govern the strategic direction of a company.

Enterprise systems (ES) aim to support the business processes of an organisation across any functional boundaries that exist within that organisation. The main types of enterprise system are:

- Enterprise resource planning (ERP) which is concerned with internal production, distribution and financial processes.
- Customer relationship management (CRM) which is concerned with marketing and sales processes.
- Supply chain management (SCM) which is concerned with the flow of materials, information and customers through the supply chain.
- Supplier relationship management (SRM) which is concerned with sourcing, purchasing and the warehousing of goods and services.

10.4.3 Process Technology for Customers

One approach to improving service delivery is to encourage the participation of the customer in the service delivery process itself. The customer can be enabled by technology to avail themselves of the service at a time of their choosing and to make choices regarding that service. From a service provider viewpoint this has the advantage of reducing staffing requirements and empowering customers by giving them a greater sense of control over the type of service they require. ATM technology can be used to provide self-service banking facilities. A choice between self-service and being served by a person in the bank is often provided.

10.5 Product/Service and Process Design

In services generally the service 'product' and the process that develops it are developed together.

In manufacturing the product may be developed separately from the process and vice versa. However when designing a manufactured product it is good practice to consider the effect on process design because choices made during product development, for example choice of materials, will effect the manufacturing process as well as the product function. In general the effectiveness and efficiency of the product development effort will depend on the management of the overlap between product and process development.

10.5.1 The Design Process

Although different organisations will approach the design process differently it can be generally seen to be composed of the following steps:

1. Idea Generation
2. Feasibility Study
3. Preliminary Design
4. Final Design

The stages are not necessarily sequential but the order may vary and the development process may cycle back and forth between stages as the design is refined. One stage may begin before the previous stage has completed (called simultaneous development).Simultaneous development is when contributors to the stages of the design effort provide their expertise together throughout the design process as a team. This contrasts with the traditional sequential design process when work is undertaken within functional departments. The problem with the traditional approach is the cost and time involved in bringing the product to market. Concurrent design reduces the time wasted when each stage in the design process waits for the previous stage to finish completely before it can commence.

Idea Generation

Ideas for new products and services can come from a variety of sources, including the organisation's research and development (R&D) department, suggestions from customers, market research data, salespeople, competitor actions or developments in new technology.

- *The Research and Development function*
  For an organisation that has a strategy of being first to the market with a new product or service, ideas will be devised principally from the organisation's own R&D department.
- *Competitors*
  Competitors can provide a good source of ideas and it is important that the organisation analyses any new products or services as they are introduced to the market and make an appropriate response.

Feasibility Study

Once a concept has been formulated it must then be submitted to a market, economic and technical analysis in order to assess its feasibility

- Market analysis
  This consists of evaluating the design concept with potential customers through interviews, focus groups and other data collection methods.

- Economic Analysis
  This consists of developing estimates of production and delivery costs and comparing them with estimates of demand.

- Technical Analysis
  This consists of determining whether the technical capability to manufacture the product or deliver the service exists.

Preliminary Design

Design concepts that pass the feasibility stage enter preliminary design. The specification of the concept - what product or service should do to satisfy customer needs - is translated into a technical specification of the components of the package (the product and service components that satisfy the customer needs defined in the concept) and the process by which the package is created. The specification of the components of the package requires a product and service structure which describes the relationship between the components and a bill of materials (BOM) or list of component quantities derived from the product structure.

Final Design

The final design stage involves refining the preliminary design through the use of a prototype until a viable final design can be made. A prototype could be to pilot a new retail store design to test customer reaction. Simulation Modelling can be used to build a computer-based prototype of a product or service design. The final design will be assessed in three main areas of functional design, form design and production design.

Functional design is ensuring that the design meets the performance characteristics that are specified in the product concept. Two aspects of functional design are reliability and maintainability. Reliability measures the probability that a product or service will perform its intended function for a specified period of time under normal conditions of use. Maintainability considers the cost of servicing the product or service when it is in use.

Form design refers to the product aesthetics such as look, feel and sound if applicable. Production design involves ensuring that the design takes into consideration the ease and cost of manufacture of a product (i.e. that the product/service design considers the process design).

10.5.2 Mass Customisation

Mass customisation is based on the assumption that market requirements are becoming increasingly fragmented, while operations resources are allowing a greater degree of flexibility and responsiveness. Therefore mass customisation aims to 'mass produce' a basic family of products or services which can still be customised to the needs of individual customers. In terms of product and service design this will often involve the standardisation and modularisation of components to increase variety while reducing production costs.

10.5.3 Service Design

In service design the overall set of expected benefits that the customer is buying is termed the service concept. The service will usually consist of a combination of goods and services and is termed the service package. In service design it is hard to separate the service 'product' from the process that produces it so when developing new services the processes that produce those services are usually designed at the same time.

Fitzsimmons(2008) defines the service package as a bundle of goods and services consisting of the following four features.

- Supporting Facility: The physical resources that must be in place before a service can be offered.
- Facilitating Goods: The material purchased or consumed by the buyer or items provided by the customer.
- Explicit Services: The benefits that are readily observable by the senses and consist of the essential or intrinsic features of the service.
- Implicit Services: Psychological benefits that the customer may sense only vaguely or extrinsic features of the service.

10.6 Job and Work Design

Operations management deals with the management of personnel that create or deliver an organisation's goods and services. Job design is concerned at the individual job level with the way in which tasks are grouped, assigned and structured in the organisation. The main elements of job and work design are behavioural aspects which impact on employee motivation and physical effects of work such as the interaction with physical devices and the environment.

10.6.1 Behavioural Aspects of Job Design

Motivation can be viewed as a social influence process which involves the question of how do we motivate employees to perform well? If employees that are not motivated they will be dissatisfied and this will lead to a poor perception of service quality by customers. A theory which has had a significant impact on the behavioural aspects of job design is the job characteristics model. The model proposes five desirable core characteristics for a job that will lead to desirable mental states. The presence of the first 3 characteristics will lead to desirable mental states in terms of meaningful work.

- Skill Variety (SV) - The extent to which a job makes use of different skills and abilities.
- Task Identity (TI) - The extent to which a job involves completing a whole identifiable piece of work.
- Task Significance (TS) - The extent to which a job has an impact on other people, both inside or outside the organisation.

The presence of the fourth characteristic will lead to desirable mental states in terms of responsibility for outcomes of work.

- Autonomy (AU) - The extent to which the job allows the jobholder to exercise choice and discretion in their work

The presence of the fifth characteristic will lead to desirable mental states in terms of knowledge of the results of work.

- Feedback (FB) - The extent to which the job itself (as opposed to other people) provides the jobholder with information on their performance.

The 5 job characteristics can be measured on a 7 point scale using an opinion questionnaire (Job Diagnostic Survey (JDS)). The scores can then be combined to provide a motivating potential score (MPS) where MPS = ((SV+TI+TS)/3) x AU x FB

This formula implies:

- Low scores in SV, TI or TS can be compensated by one another
- SV, TI and TS combined are only as important as AU and FB alone
- A near zero rating on AU or FB will pull down the score disproportionately.

The five core job characteristics in turn stimulate 3 psychological states:

- Experienced meaningfulness – the extent to which the individual considers the work to be meaningful, valuable and worthwhile
- Experienced responsibility – the extent to which the individual feels accountable for the work output
- Knowledge of results – the extent to which individuals know and understand how well they are performing

If *all* of these psychological states are present it should in turn lead to higher motivation and quality of work performance.

The relationships in the model are contingent. The model only applies to people who have an interest in developing themselves, applying their skills and taking responsibility, termed growth-need strength (GNS). The model may not apply to people who are actively dissatisfied with the context of their work (e.g. offensive working conditions). The model assumes sufficient skills have been attained and sufficient resources have been provided to do the job.

10.6.2 Physical Aspects of Job Design

In addition to behavioural factors job design should consider the physical effects of work. The term ergonomics is used to describe the collection of information about human characteristics and behaviour to understand the effect of design, methods and environment. Two areas of major concern are the interaction with physical devices, such as computer terminals, and with the environment, such as the office.

When required to operate a physical device a worker must be able to reach the controls and apply the necessary force to them. Although the average person is capable of a variety of tasks, the speed and accuracy of any actions can be affected by the location of a device. Because the human part of this system cannot obviously be designed, considerable thought must be placed into the location of the device taking into account human capabilities. Anthropometric data is information concerning factors related to the physical attributes of a human being, such as the size, weight and strength of various parts of the human body. From this information it is possible to gather data on the range of motion, sitting height, strength, working height and other variables.

Environmental design involves the immediate environment in which the job takes place. Some environmental variables to consider include:

- Noise: Excessive noise levels can not only be distracting but can lead to damage to the worker's hearing.
- Illumination: The level of illumination depends on the level of work being performed.
- Temperature and Humidity: Although humans can perform under various combinations of temperature, humidity and air movement, performance will suffer outside of an individual 'comfort zone'.

10.6.3 Work Study – Measuring Job Performance

Work Study can be traced back to F.W.Taylor's work in developing scientific management approaches to find the best way to conduct work. It has been developed to measure the performance of jobs, consists of two elements, work measurement and method study.

Work measurement determines the length of time it will take to undertake a particular task.

The time needed to perform each work element can be determined by the use of historical data, work sampling or most usually time study.

- Time Study
  The use of statistical techniques to arrive at a standard time for performing one cycle of a repetitive job.

- Predetermined motion times:
  These provide generic times for standard micromotions such as reach, move and release which are common to many jobs.

- Work Sampling
  A method for determining the proportion of time a worker or machine spends on various activities and as such can be very useful in job redesign and estimating levels of worker output.

Organisations have often used learning curves to predict the improvement in productivity that can occur as experience is gained of a process. Learning curves are usually applied to individual operators, but the concept can also be applied in a more aggregate sense, termed an experience or improvement curve, and applied to such areas as manufacturing system performance or cost estimating. Industrial sectors can also be shown to have different rates of learning. It should be noted that improvements along a learning curve do not just happen and the theory is most applicable to new product or process development where scope for improvement is greatest.

Method study involves examining working methods in order to identify the most efficient approach. This involves dividing and analysing a job.

10.6.4 Job Design Approaches

Job design can relate to a new job but more typically to a current job for reasons such as a need to increase productivity, introduce new technology or improve motivation. Job design approaches include:

- Job Simplification
- Job Rotation, Job Enlargement and Job Enrichment
- Empowerment
- Autonomous Work Teams
- High Performance Work Systems

Job Simplification

This aims to reduce the complexity of work by minimising the range of tasks. It is often seen in assembly lines when workers stay in a fixed position and the components move down an assembly line, but also can be seen in many office jobs. An attempt to maximise output, based on the scientific management approach. Criticised for reducing motivation through lack of control over work, repetitiveness and reduced social interaction.

Job Rotation

Involves the combination of two or more simplified jobs into a rotating pattern of work. May involve a worker changing job roles with another worker on a periodic basis. Problems are that it requires training in all job roles and may limit the level of specialised knowledge developed. Does not actually improve job design of each job and can just mean rotating between a number of boring jobs. Can provide higher flexibility for management and may reduce monotony and boredom.

Job Enlargement (Horizontal Job Enlargement)

This involves the horizontal (same level) integration of tasks to expand the range of tasks involved in a particular job. Problems are that it may not be efficient to combine jobs and it is usually restricted to combining simple assembly line jobs which then may become monotonous once again. Can make a more meaningful job due to range of tasks and thus improve motivation.

Job Enrichment (Vertical Job Enlargement)

This involves the vertical (different level) integration of tasks and the integration of responsibility and decision making. This can increase motivation through a wider range of tasks, more responsibility and feedback. The Job Characteristics model is one approach to job enrichment.

Empowerment

The ideas of job enrichment have led to the concept of empowerment. Autonomy has been defined as to the extent to which the job allows the jobholder to exercise choice and discretion in their work. Empowerment however is about giving staff authority to make changes to the job itself, as well as how it is performed. Empowerment can be seen not just as a matter of providing autonomy but as a process which starts with the creation of meaning and feelings of competence and then evolves towards levels of self-determination, impact and autonomy. (i.e. before giving someone responsibility for their job design it is better if they value what they are doing and feel they can do it).

Autonomous Work Groups

In the last two decades there has been a shift towards more team and group based work and strategies to increase motivation and performance at the group level. Autonomy at the group level relates to the collective autonomy for the workers as a team to do a task. The approach proposes that a group or team would be able to decide on their own methods of working and should be responsibility for handling problems as they arise.

High Performance Work Systems (HPWS)

HPWS are a converging of individual job enrichment and autonomous work groups. They involve reforms to work practices to:

- increase employee involvement in decision making
- investments in employee skills
- changes in performance incentives

These changes are designed to ensure employees can undertake greater responsibilities and want to do so HPWS are in contrast to the 'Taylorist' (scientific management) highly specialised, de-skilled jobs.

11 Infrastructural Decisions

11.1 Planning and Control

Planning and Control in Operation is about reconciling market requirements (demand) with the operation's resources (supply). Planning determining the timing and nature of actions that should take place in the future. Control is when as the operation is ongoing, determining what action to take if there is a significant deviation from what should be happening. In reality planning and control activities are intertwined in an ongoing organisation.

The nature of planning and control in operations is dependent on:

1. Time horizon of planning and control activities
2. The nature of demand on the operation
3. Market requirements (volume/variety)

11.1.1 Time horizon for planning & control

Long-Term Operations Planning

18 months+, concerned with structural decisions such as location, layout, supply network

Medium-Term Operations Planning

1-18 months, concerned with how operation will meet demand for products and services in the medium term. Provides monthly capacity plan to meet demand.

Short-Term Operations Planning

1-4 weeks, Activity scheduling concerns assigning work on a daily basis to work centre (i.e. team, individual or machine). Involves activities of loading, sequencing and scheduling. Expediting takes place in real-time and concerns intervening in day-to-day operations in order to reschedule activities to meet short-term requirements.

11.1.2 Nature of demand on Planning and Control activities

The predictability of demand for goods and services can range from a situation of what is essentially dependent demand (i.e. demand can be predicted) to a high level of unpredictability (independent demand). Dependent demand is often for components of a product. For example when a forecast for product demand has been made (independent demand) then we can predict the amount of demand for the components of that product by examining the bill of materials and taking into account the amount of inventory on hand. Planning policies to meet different types of demand are as follows:

Resource-to-Order

In a dependent demand type situation it is not necessary to activate a planning system and acquire resources until a delivery date for an order is received. Relates to construction and project based operations

Make-to-Order

For independent demand when demand is relatively predictable transforming resources such as staff and machinery may be in place on a permanent basis. However the transformed resources, i.e. the raw material which is used to construct the product, may be acquired on the receipt of a customer order. (probably only option for services). Despite the risk of stock-outs many manufacturers and retailers use this strategy as it decreases the amount of inventory through the supply chain.

Make-to-Stock

If demand is unpredictable, the organisation will use of make-to-stock planning policy which produces to a forecast of demand for the product. Retailers may need the products on show for people to buy.

The P:D ratio is a concept that compares the demand time D (from customer request to receipt of goods/services) to the total throughput time P of the purchase, make and delivery stages. In a resource-to-order system the demand time and throughput time are essentially the same. The purchase-make-deliver cycle is not triggered until a customer order is received. Thus the purchase, make and deliver stages all effect delivery performance. In a make-to-stock system the demand time is essentially the time of delivery from stock to the customer. Thus the customer only 'sees' the delivery time. However although delivery performance is improved in a make-to-stock system, the item is being produced to a forecast demand which is subject to error.

11.1.3 Market Requirements

Low Volume/High variety

Will involve a short planning horizon and detailed control decisions. Customer demand time will be relatively high. e.g. consultancy will need to respond to customer requests individually and on an on-going basis.

High Volume/Low Variety

Will involve a long planning horizon and aggregated control decisions. Customer demand time will be relatively short. e.g. mass production of a product to stock.

11.1.4 Activity Scheduling

This typically occurs over a timeframe of 1-4 weeks and is concerned with assigning work on a daily basis to a work centre (i.e. team, individual or machine). Involves:

- loading (determining capacity and volumes).
- sequencing (deciding on the order of execution of work).
- scheduling (allocating start and finish time to a customer order).

Loading involves determining the available capacity for each work centre in a process and allocating work to that centre. The calculation of actual available capacity will need to take account of planned and unplanned factors. There are two principle approaches to loading. Finite loading allocates work up to an agreed fixed (finite) upper limit (e.g. seats on an aircraft). Infinite loading does not place a limit on the work loaded onto a stage. This may be because it is not possible to limit demand (a queue will form if demand exceeds capacity).

Sequencing (also known as dispatching) is the sequential assignment of tasks or jobs to individual processes. In order to attempt to control the progress of a job through a process a job priority system may be used. Priority rules include:

- DDS (Customer Due-Date) - Job with nearest customer due-date to the current date – emphasises delivery reliability
- FCFS (First come, first served) - Job arriving first at a process (i.e. in order of arrival) – seen as 'fair' in customer processing
- SPT (Shortest Process Time) Job with shortest process time among waiting jobs – gets jobs out fast to get cash in
- LPT (Longest Process Time) - Job with longest process time among waiting jobs – means high utilisation but can affect delivery speed overall

Other sequencing rules could give priority to 'important' customers or may be constrained by the nature of the process (e.g. dying textiles).

Scheduling is the allocation of a start and finish time to each order while taking into account the loading and sequencing policies employed. Used where some planning ahead is needed to ensure customer demand is met. The approach to scheduling in manufacturing is largely dependent on the volume and variety mix of the manufacturing system itself and so scheduling approaches will be considered under the headings of mass, batch and jobbing process types.

- *Mass process type scheduling*
  Mass process type systems produce a standard product in a relatively high volume. These systems which have a characteristic flow (product) layout use specialised equipment dedicated to achieving an optimal flow of work through the system. This is important because all items follow virtually the same sequence of operations.

- *Batch process type scheduling*
  Scheduling in these configurations is a matter of ensuring that the batch of work introduced to the process will be completed to meet customer due dates. The MRP approach is often used to determine the batch size and timing (job sequence) of jobs to meet a projected demand expressed in the form of a master production schedule (MPS) that is developed from customer orders and demand forecasts. An aim of the JIT system is to eliminate this inventory and make the production control process more transparent. An OPT system will focus on ensuring that the bottleneck processes are kept busy as they determine the output of the whole process.

- *Jobbing process type scheduling*
  A jobbing system deals with a number of low volume, high variety products. Each product is customised to a customer order and so the production planning and control system must deal with a changing mix of jobs. Because the job may not have been produced before it may be difficult to estimate the elements of lead time for each job. The technique of job sequencing is used to schedule in jobbing type systems.

11.1.5 Expediting

This is intervening on a day-to-day basis to reschedule activities. Expediting may be needed because of:

- Material shortage
- Customer order change
- Equipment breakdown
- Staff absence

Expediting should be minimised because of potential knock-on effects on schedule which may lead to more expediting and the schedule is not followed.

11.2 Inventory Management

Inventory is present in all service and manufacturing processes. In manufacturing inventory consists of the components that go to make up the product being manufactured. In services inventory may be used as part of the service delivery system (for example disposable implements for a hospital operation) or be part of the tangible component of the service itself (for example the brochure for a car insurance policy). Inventory is important because although it is necessary for customer service it can also be a major cost to the organisation. Inventory can be classified by location or by type.

Inventory classified by location:

- raw materials (goods received from suppliers)
- work-in-progress (at some point within the operations process)
- finished goods (goods ready for dispatch to the customer)

Inventory classified by type

- *Buffer/Safety* This is used to compensate for the uncertainties inherent in the timing or rate of supply and demand between two operational stages.
- *Cycle* If it is required to produce multiple products from one operation in batches, there is a need to produce enough to keep a supply while the other batches are being produced.
- *De-Coupling* This permits stages in the manufacturing process to be managed and their performance measured independently.
- *Anticipation* This includes producing to stock to anticipate an increase in demand due to seasonal factors.
- *Pipeline/Movement* This is the inventory needed to compensate for the lack of stock while material is being transported between stages.

11.2.1 Managing Inventory

One of the major issues in inventory management is the level of decentralisation required in inventory distribution. Decentralised facilities offer a service closer to the customer and thus should provide a better service level in terms of knowledge of customer needs and speed of service. Centralisation however offers the potential for less handling of goods between service points, less control costs and less overall inventory levels due to lower overall buffer levels required. Thus there is a trade-off between the customer service levels or effectiveness offered by a decentralised system and the lower costs or efficiency offered by a centralised system.

11.2.2 The ABC classification system

The ABC classification system sorts inventory items into groups depending on the amount of annual expenditure they incur:

- **A items** are the 10-20% of items that account for 60-80% of expenditure. These items need to be controlled closely to reduce costs.
- **B items** account for the next 20-30% of items and usually account for a similar percentage of total expenditure. These items require fewer inventory level reviews than A items.
- **C items** represent the remaining 50-70% of items but only account for less than 25% of total expenditure. Here less rigorous inventory control methods can be used, as the cost of inventory tracking will outweigh the cost of holding additional stock.

11.2.3 Inventory Models

Inventory models are used to assess when inventory requires ordering and what quantity should be ordered at that point in time. In a fixed order *quantity* inventory system, inventory is ordered in response to some event, such as inventory falling to a particular level.

- The timing of the inventory order can be calculated using a Re-order Point (ROP) Model.
- The quantity to order at this point in time may be calculated using the Economic Order Quantity (EOQ) model.

In a fixed order *period* inventory system, inventory is ordered at a fixed point in time.

- A fixed-order inventory (FOI) model can be used to determine the quantity to order at a fixed point in time.

The Re-Order Point (ROP) Model

The Reorder point model identifies the time to order when the stock level drops to a predetermined amount. This amount will usually include a quantity of stock to cover for the delay between order and delivery (the delivery lead time) and an element of stock to reduce the risk of running out of stock when levels are low (the safety stock). To calculate the safety stock level a number of factors should be taken into account including cost due to stock-out, cost of holding safety stock, variability in rate of demand and variability in delivery lead time.

The Economic Order Quantity (EOQ) Model

The Economic Order Quantity (EOQ) model calculates the fixed inventory order volume required while seeking to minimise the sum of the annual costs of holding inventory and the annual costs of ordering inventory. The model makes a number of assumptions including stable or constant demand, fixed and identifiable ordering cost, the item cost does not vary with the order size and the delivery lead time does not vary.

Fixed Order Inventory (FOI) Model

This can be used to calculate the amount to order given a fixed interval between ordering.

The calculation for the FOI model is dependent on whether demand and delivery lead time are treated as fixed or variable.

11.2.4 Implementing Inventory Systems

Inventory management can be outsourced which is sometimes referred to as vendor managed inventory. An example of this is when wholesalers hold stocks for a number of retailers. This allows the retailers to focus on selling activities and order stock from the wholesaler as needed. A number of e-business solutions are available in the area of inventory management which are usually provided as a module within a supply chain management or material management e-business system.

11.3 Capacity Management

The setting of capacity to meet the demands of the organisation is termed capacity management. The capacity management activity should be taken using a systematic approach using the following steps:

1. Measure Demand
2. Measure Capacity
3. Reconcile Capacity and Demand
4. Evaluate alternatives and make a choice

11.3.1 Measure Demand

This is usually the responsibility of marketing. Am accurate demand forecast is needed of the units of capacity required over the medium term (not just income). Because a forecast can never be completely accurate it is useful to have a estimate of how much the demand might vary around an average value. Demand Forecasts may well after take into account:

- Seasonality Effects over a year. Demand Seasonality due to climate, social, financial etc. and supply seasonality, eg. Food
- Demand may also fluctuate over days and weeks.

Accurate forecasts are an important factor in enabling organisations to deliver goods and services to the customer when required and thus achieve a quality service. The accuracy of a forecast is also dependent on the time horizon over which the forecast is derived. Forecasts for short time horizons tend to be more accurate than for longer-term forecasts, so one way of improving accuracy is shortening the lead-time necessary for the organisation to respond to a forecast. In order to produce accurate forecasts an organisation must collect up-to-date data on relevant information such as prices and sales volumes and choose an appropriate forecasting technique.

11.3.2 Measure Capacity

Capacity is not fixed but is a variable that is dependent on a number of factors. Capacity takes many different forms such as storage space, employee skills availability, equipment numbers and transportation facilities. Capacity is time-based and so capacity under-utilised due to a drop in demand cannot be used later when demand increases. Thus the actual capacity available will be less the more demand fluctuates.

Further factors that effect the measurement of capacity include the location of capacity. In services the time spent travelling to the location of the service delivery point can effect capacity. For example more letters can be delivered by one person in a city than in the country. Professional services will require extension customer contact which may vary greatly depending on the individual customer's needs. The effective capacity of the whole system may depend on a bottleneck resource. Two further issues to consider when measuring capacity are product mix and the definitions of design capacity.

Only when a narrow product (or service) range is involved can capacity be measured reasonably accurately and in this case be quoted in terms of output volume. With a changing product mix therefore it may be more useful to measure capacity in terms of input measures, which provides some indication of the potential output. For example in hospitals which undertake a range of activities, capacity is often measured in terms of beds available, an input measure. An output measure such as number of patients treated per week will be highly dependent on the mix of activities the hospital performs

11.3.3 Reconcile Capacity and Demand

Methods for reconciling capacity and demand can be classified into three 'pure' strategies of:

- Level Capacity
- Chase Demand
- Demand Management.

Level Capacity

This capacity planning strategy sets processing capacity at a uniform level throughout the planning period regardless of fluctuations in forecast demand. This means production is set at a fixed rate, usually to meet average demand and inventory is used to absorb variations in demand. For a service organisation output cannot be stored as inventory so a level capacity plan involves running at a uniformly high level of capacity. High utilisation, but poor service levels may result if this level is not sufficiently high.

Chase Demand

This strategy seeks to match output to the demand pattern over time. Capacity is altered by such policies as changing the amount of part-time staff, changing the amount of staff availability through overtime working, changing equipment levels and subcontracting. The chase demand strategy is costly in terms of the costs of activities such as changing staffing levels and overtime payments. The costs may be particularly high in industries in which skills are scarce.

Demand Management

While the level capacity and chase demand strategies aim to adjust capacity to match demand, the demand management strategy attempts to adjust demand to meet available capacity. There are many ways this can be done, but most will involve altering the marketing mix (e.g. price, promotion etc.) and will require co-ordination with the marketing function.

11.3.4 Evaluate alternatives & make a choice

Capacity management involves evaluating the capacity requirements and determining the best way to meet these using a capacity management approach which is feasible and low cost. In order to choose a capacity plan which meets the above criteria it is necessary to try to predict the consequences of that plan. This can be done with varying levels of accuracy and cost using the following methods:

- Cumulative Representations
  A running total or cumulative count of inventory, which should always meet or exceed cumulative demand. It is used to ensure no stock-outs occur when using a level capacity plan.

- Queuing Theory and Simulation
  Waiting time in queues is caused by fluctuations in arrival rates and variability in service times. Queuing theory can be used to explore the trade-off between the amount of capacity and the level of demand. Equations are given for single channel and multiple channel systems. These equations have been criticised because they make a number of assumptions. Simulation can give a more accurate estimate of capacity than queuing theory for a particular product mix.

- The Psychology of Queuing
  A series of propositions which can be used by service organisations to instigate policies to influence customer satisfaction with waiting times. For example unoccupied time feels longer than occupied time, anxiety makes waits seem longer, unexplained waits are longer than explained waits and the more valuable the service the longer the customer will wait. These propositions may lead to the use of signs informing customers of how long they will need to wait for service for example.

11.4 Supply Chain Management

Within structural decisions the configuration of the organisation's relationship with its suppliers and customers is termed the supply network. A supply chain can be defined as one of the series of linkages from suppliers to customers within the supply network. Supply Chain Management is the *management* of the flow of materials through the supply chain.

The terms used in the area of supply chain management are defined in a number of ways and so the most common terms are first defined:

- Procurement (Inbound logistics): This is used to describe the activity of moving material in from suppliers.
- Physical Distribution Management (Outbound logistics): This is used to describe the activity of moving materials out to customers.
- Materials Management: The movement of materials within the organisation.

Supply Chain Management will de discussed in terms of:

- Fluctuations in the supply chain
- Supply Chain Integration
- Procurement
- Physical Distribution Management

11.4.1 Fluctuations in the Supply Chain

The behaviour of supply chains that are subject to demand fluctuations has been described as the Forrester effect or bullwhip effect as described by Jay Forrester. The effect occurs when there is a lack of synchronisation is supply chain members, when even a slight change in consumer sales will ripple backwards in the form of magnified oscillations in demand upstream. In order to limit the bullwhip effect certain actions can be taken. The major aspect that can limit supply chain variability is to share information amongst members of the supply chain. In particular it is useful for members to have access to the product demand to the final seller, so that all members in the chain are aware of the true customer demand. Avoiding price promotions (thereby increasing demand) and using smaller batch sizes will also smooth the demand pattern

11.4.2 Supply Chain Integration

Organisations in a supply chain can have varying degrees of cooperation and integration. The organisation must make a strategic decision about what it keeps 'in-house' and what it outsources. In order of increasing ownership the options are:

- market relationship,
- strategic partnerships and alliances
- virtual organisation
- vertical integration

Market Relationships

Here each purchase is treated as a separate transaction and the relationship between the buyer and seller lasts as long as this transaction takes. There can be some additional arrangements around this relationship such as the use of electronic data interchange (EDI) facilities to share information, combining orders in a single delivery to reduce transportation costs, agreements on packaging standards to improve materials handling and other factors. This approach does have a number of advantages in that it permits flexibility in that suppliers can be changed or discontinued if demand drops or a supplier introduces a new product. However there can be disadvantages in this arrangement in that either side can end the relationship at any time.

Strategic Partnerships and Alliances

This involves a long-term relationship in which organisations work together and share information regarding aspects such as planning systems and development of products and processes. The idea of a partnership or alliance is to combine the advantages of a marketplace relationship which encourages flexibility and innovation with the advantages of vertical integration which allows close coordination and control of such aspects as quality. From a supplier viewpoint a long-term strategic partnership may give them the confidence to invest in resources and focus on a product line to serve a particular customer.

The Virtual Organisation

The form of an organisation's relationship within its supply chain is increasingly being affected by developments in e-business systems. E-business involves electronically mediated information exchanges, both within an organisation and between organisations.

Vertical Integration

Complete integration is achieved by an organisation when they take ownership of other organisations in the supply chain. The amount of ownership of the supply chain by an organisation is termed its level of vertical integration. When an organisation owns upstream or supply-side elements of the supply chain it is termed backward vertical integration. For ownership of downstream or demand-side elements of the supply chain is termed forward vertical integration. When a company owns elements of a different supply chain, for example a holding company which has interests in organisations operating in various markets, the term used is horizontal integration.

One potential advantage of vertical integration is the ability to secure a greater control of the competitive environment. Backward integration, implemented by owning suppliers, can secure supplies of components whose availability and price to competitors can be controlled. Another reason for vertical integration is to keep distinctive competence or capability in-house and not available to competitors. A disadvantage of vertical integration and perhaps the major reason for outsourcing is the cost incurred in owning major elements of the supply chain. This means there is a risk in that trying to do everything will mean that the company is not competitive against companies who are focusing their resources and skills on particular elements of the supply chain. Another factor is that the increased flexibility available when using a number of suppliers to meet fluctuations in demand.

11.4.3 Procurement

The role of procurement is to acquire all the materials needed by an organisation in the form of purchases, rentals, contracts and other acquisition methods. The procurement process also includes activities such as selecting suppliers, approving orders and receiving goods from suppliers. The term purchasing usually refers to the actual act of buying the raw materials, parts, equipment and all the other goods and services used in operations systems. However the procurement process is often located in what is called the purchasing department. Procurement is an important aspect of the operations function as the cost of materials can represent a substantial amount of the total cost of a product or service.

Choosing Suppliers

Before choosing a supplier, the organisation must decide whether it is feasible and desirable to produce the good or service in-house. Buyers in purchasing departments, with assistance from operations, will regularly perform a make-or-buy analysis to determine the source of supply. If a decision is made to use an external supplier, the next decision relates to the choice of that supplier. Criteria for choosing suppliers for quotation and approval include price, quality and delivery.

11.4.4 Physical Distribution Management

Physical Distribution Management, sometimes called business logistics, refers to the movement of materials from the operation to the customer. Four main areas of physical distribution management are:

- materials handling
  Materials handling relates to the movement of materials, either within warehouses or between storages areas and transportation links. The aim of materials handling is to move materials as efficiently as possible. The type of materials handling systems available can be categorised as manual, mechanised and automated.
- Warehousing
  When producing a tangible item it is possible to provide a buffer between supply and demand by holding a stock of the item. Many organisations have specific locations to hold this stock, termed a warehouse or distribution centre.
- packaging
  Packaging provides a number of functions including identifying the product, giving protection during transportation and storage, making handling easier and providing information to customers. The emphasis put on each of these factors will depend on the nature of the product, with protection being a major factor for some products.
- transportation
  Distribution is an important element of the supply chain and can account for as much as 20% of the total costs of goods and services. The amount of cost will depend largely on the distance between the company and its customers and the method of transportation chosen.

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