JEPPIAAR
ENGINEERING COLLEGE

BATCH 2021 – 2023
I YEAR / II SEMESTER

BA 4204 – OPERATION MANAGEMENT

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REGULATION 2021
ANNA UNIVERSITY CHENNAI – 25

JEPPIAAR ENGINEERING COLLEGE

VISION:

Jeppiaar Engineering College intent to be a leading, comprehensive school of management, furthering our global reputation for educational experiences that make a difference in the lives of our students. Through our actions and accomplishments, we will inspire pride among the diverse members of our community. We will be renowned for adding value and engaged service. We continue the upward increase in rankings and scholarly productivity.

MISSION:

- To provide management education to all groups in the community.
- To practice management through scholarly research and education.
- To advance the practice of management within a global context,
- To provide management education to advance professional and community service.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

- To have a thorough understanding of the core aspects of the business
- To provide the learners with the management tools to identify, analyze and create business opportunities as well as solve business problems.
- To inspire and make them practice ethical standards in business.

PROGRAMME OUTCOMES (POs)

- Apply knowledge of management theories and practices to solve business problems.
- Foster Analytical and critical thinking abilities for data-based decision making.
- Ability to develop Value based Leadership ability.
- Ability to understand, analyze and communicate global, economic, legal, and ethical aspects of business.
- Ability to lead themselves and others in the achievement of organizational goals, contributing effectively to a team environment.
- Ability to upgrade their professional and managerial skills in their workplace.
- Ability to pursue lifelong business learning and fulfilling business career.

JEPPIAAR ENGINEERING COLLEGE [MBA]

VISION:

To build Jeppiaar Engineering College [MBA] as an institution of academic excellence in management education, leading to become a world class university.

MISSION:

- To excel in teaching and learning, research and innovation by promoting the principles of scientific analysis and creative thinking.
- To participate in the production, development and dissemination of knowledge and interact with national and international communities.
- To equip students with values, ethics and life skills needed to enrich their lives and enable them to contribute for the progress of society.
- To prepare students for higher studies and lifelong learning, enrich them with the practical skills necessary to excel as future professionals and entrepreneurs for the benefit of Nation's economy.

COURSE OBJECTIVE:

- To provide a broad introduction to the field of operations management and explain the concepts,strategies, tools and techniques for managing the transformation process that can lead to competitive advantage.

COURSE OUTCOMES:

1. Understanding of the evolution of operations management practices and world classmanufacturing processes
2. Knowledge about capacity planning, strategic sourcing and procurement in organizations
3. Enhances the understanding of product development and design process
4. Ability to forecast demand and overcome bottlenecks
5. Provides insight to Quality management tools and practices

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	0	3	0	2
CO2	3	3	0	3	0	2
CO3	3	3	0	3	0	2
CO4	3	3	0	3	0	2
CO5	3	3	0	3	0	2
AVERAGE	**3**	**3**	**0**	**3**	**0**	**2**

OPERATIONS MANAGEMENT

UNIT I INTRODUCTION TO OPERATIONS MANAGEMENT **9**

Operations Management – Nature, Importance, historical development, transformation processes, differences between services and goods, a system perspective, functions, challenges, current priorities, recent trends. Operations Strategy – Strategic fit , framework. Productivity; World-class manufacturing practices

UNIT II OPERATIONS AND THE VALUE CHAIN **9**

Capacity Planning – Long range, Types, Developing capacity alternatives, tools for capacity planning. Facility Location – Theories, Steps in Selection, Location Models. Sourcing and procurement - Strategic sourcing, make or buy decision, procurement process, managing vendors.

UNIT III DESIGNING OPERATIONS **9**

Product Design - Criteria, Approaches. Product development process - stage-gate approach - tools for efficient development. Process - design, strategy, types, analysis. Facility Layout – Principles, Types, Planning tools and techniques.

UNIT IV PLANNING AND CONTROL OF OPERATIONS **9**

Demand Forecasting – Need, Types, Objectives and Steps - Overview of Qualitative and Quantitative methods. Operations planning - Resource planning - Inventory Planning and Control. Operations Scheduling - Theory of constraints - bottlenecks, capacity constrained resources, synchronous manufacturing

UNIT V QUALITY MANAGEMENT **9**

Definitions of quality, The Quality revolution, quality gurus; TQM philosophies; Quality management tools, certification and awards. Lean Management - philosophy, elements of JIT manufacturing, continuous improvement. Six sigma.

TOTAL : 45 PERIODS

Reference

1. Richard B. Chase, Ravi Shankar, F. Robert Jacobs, Operations and Supply Chain Management,McGraw Hill Education (India) Pvt. Ltd, 14th Edition, 2014.
2. Mahadevan B, Operations management: Theory and practice. Pearson Education India; 2015.
3. William J Stevenson, Operations Management, Tata McGraw Hill, 9th Edition, 2009.
4. Russel and Taylor, Operations Management, Wiley, 5th Edition, 2006.
5. Norman Gaither and Gregory Frazier, Operations Management, South Western CengageLearning,9 th edition, 2015.
6. Cecil C. Bozarth, Robert B. Handfield, Introduction to Operations and Supply Chain Management,Pearson, 4th Edition, 2016.
7. Panneerselvam. R, Production and Operations Management, 3rd Edition,. PHI Learning, 2012.

BA4104 OPERATION MANAGEMENT

Unit I

What does operations management involve?

Operations management is chiefly concerned with planning, organizing and supervising in the contexts of production, manufacturing or the provision of services. As such, it is delivery- focused, ensuring that an organization successfully turns inputs to outputs in an efficient manner.The inputs themselves could represent anything from materials, equipment and technology to human resources such as staff or workers.

Examples of the types of duties or specialist positions this encompasses are procurement (acquiring goods or services from external sources), managing relations with those involved in processes and improving a company's sustainability with regard to their use of resources.

There are two key terms that can help answer the question of what operations management is more precisely: **supply chain management** and **logistics**. Operations management has firm foundations in both areas. For example, understanding global trends in supply chain management in order to meet client demand is often critical. With logistics the careful and considered use of resources, as well as cost-effectiveness, has become increasingly important in an era in which resources can often be in short supply and customer expectations have

What is Operations Management?

Operations management is the management of processes that transform inputs into goods and services that add value for the customer.

Operation Management means the administration of business activities for attaining higher efficiency. It is a process of planning, organizing, and supervising the operations of the business for better productivity. Operation management aims at reducing the cost to business by avoiding any wastage of resources.

FUNCTION OF OPERATION MANAGEMENT

- **Finance-** Finance plays a main function in operations management. The operation manager should not waste finance in unproductive tasks. He should ensure that all finance of the organization is utilized for the manufacturing of useful goods or services which may satisfy consumer wants.
- **Operation**– The function of operation management is basically concerned with planning, organizing, directing and controlling of daily routine operations of an organization. The operation manager ensures that all activities are going effectively and efficiently.
- **Strategy**– The strategy formulation is also the main function of operation management. The operation manager should have pre-planned tasks. Formulation of plans and tactics helps the organization in optimizing their resources and developing a competitive edge over competitors.
- **Product Design**– It is the duty of operations manager to design the product according to the market trends and demands. He should ensure that innovative techniques are incorporated within the product and its quality is maintained.

- **Maintaining Quality**– Operations managers should ensure a better quality of products. The manager should not compromise with the quality of Products. They should work on quality management and should supervise all tasks. If any defects are found they should take steps to rectify such defects.

Importance of operation management

- **Helps in achievement of objectives:** Operations management has an effective role in the achievement of pre-determined objectives of an organization. It ensures that all activities are going as per plans by continuously monitoring all operations of organization.
- **Improves Employee productivity:** Operation management improves the productivity of employees. It checks and measures the performance of all people working in the organization. Operation manager trains and educate their employees for better performance.
- **Enhance Goodwill**: Operation management helps in improving the goodwill and presence of the organization. It ensures that quality products are delivered to all customers that could provide them better satisfaction and makes them happy.
- **Optimum utilization of resources**: Operation management focuses on optimum utilization of all resources of the organization. It frames proper strategies and accordingly continues all operations of the organization. Operation managers keep a check on all activities and ensure that all resources are utilized on only useful means and are not wasted.
- **Motivates Employees:** Operation management helps in motivating the employees towards their roles. Operation managers guide all peoples in performing their roles and provide them with better atmosphere. Employees are remunerated and rewarded according to their performance level.

SCOPE OF OPERATION MANAGEMENT

- **Increase Productivity:** Operation management played an important role in increasing the productivity of business. It manages all aspects of production activities to achieve

highest efficiency possible. Operation manager are responsible for designing production plan for carrying out the operations. They ensure that all inputs used by organisations are efficiently transformed into outputs that is products or services. It is crucial for all business for properly managing their day to day activities and efficient utilisation of all its resources which helps in raising productivity.

- **Raises Revenue:** Operational management directly influences the profitability of the business. It works on reducing the cost of operations to business by reducing the wastage of resources. Operations managers monitor every production activity and take all necessary steps for maintaining efficiency in the organisation. They try to maintain an appropriate balance between cost and revenue. Maintenance of quality of products and delivering them as per customer needs is another function played by these operation managers. It helps in attracting more and more customers which increase the overall revenue of business.
- **Achievement Of Organisation Goals**: Every organisation strives towards achievement of its desired goals. Proper management of production activities helps business to properly implement their strategic plans in their operation. Operation management ensures that all operations of business are going in desired direction. It regularly monitors every activity and takes all corrective measures as required according to prevailing situations. Proper functioning of business as per strategic plans helps in achievement of desired goals.
- **Reduce Investment Need**: Operation management reduces the additional capital requirements of the business. It ensures that all capital employed in the business are efficiently used. Management of operations ensures that all production activities go uninterrupted without any shortage of capital. By increasing the efficiency and avoiding the wastage of employed resources, it avoids any deficiency of capital in business. Businesses are not required to invest more in their production activities.
- **Enhance Goodwill:** Maintaining proper goodwill in the market is the goal of every business. Operation management focuses on improving the position of the organisation in the market. It ensures that business works for providing better services to its customers. Business should manufacture durable and high-quality products that may provide better satisfaction to users. Customers will gain confidence in their products which will improve their market image.
- **Improve Innovation**: Operation management helps in implementing innovative changes in organisational activities. All decision regarding production planning is taken by operation managers by doing research and analysis of prevailing market situations. It takes into account all technological changes and builds a strong base of knowledge and operations. This helps in bringing various innovations in operations of the business.

Introduction

With the increasing competition in the manufacturing industry, many businesses have adopted the use of operations management which has been, over the years, a bridge towards a business's success as well as the economic growth of a nation. It involves the absolute control of the use of resources and other raw materials and turning them into more valuable products. Businesses have, ever since, benefited from the use of the

developments associated with the concept which has, consequently, seen great economic growth rates in many countries.

This concept began way back as manufacturing management after which it developed into operations management following the advancements of technological knowhow. The main idea of the concept, both traditional and advanced, is to promote the achievement of production goals within companies with as minimal struggle as possible.

Historical development of Operations management

- The idea of operations management began in the eighteenth century as manufacturing management. An economist, Adam Smith, realized that specialization of labor could be very beneficial to any organizations economy.
- He therefore came up with the idea of breaking up jobs into sub units where only workers specialized in a certain field would take up the task not only to ensure efficient delivery of the task but also to further increase their skills (Kumar, and Suresh, 2009, p. 284). Early in the twentieth century, F. Taylor enforced this law which then resulted to the development of scientific management. Since then until in the early nineties, many developments were made based on the traditional of the operation.
- In 1776, Adam Smith developed the theory of specialization of labor in the manufacturing industry (Kumar, and Suresh, 2009, p. 284). This was followed by development of cost accounting in 1799 by Eli Whitney among other scientists. Later in 1832, Charles Babbage developed division of labor and assigning of tasks depending on employees' skills as well as the necessity of time management (Kumar, and Suresh, 2009, p. 284).
- From the scientific management of time, Frederick Taylor developed planning and work performance in the year 1900. Soon after, in 1900, Frank Gilbert came up with the motion of studying jobs (Wilson, 995, p. 87). This was followed by the development of techniques for scheduling of work for employees as well as the development of manufacturing jobs which required the use of machinery.
- These two developments were done by Henry Gantt in 1901. In 1915, F.W. Harris developed the use of inventory for economic controls. The human relations department

was developed by Elton Mayo in 1927 (Kumar, and Suresh, 2009, p. 284). Following this development was the use of statistical information to check and control the quality of various products by use of quality control charts.

- This development was by W.A. Shewart in 1931. This contribution was further developed into sampling techniques to control quality of products and for inspection purposes in 1935 by H.F. Dodge and H.F. Roming. In 1946, a group of scientists among which was P.M. Blacker contributed in the application of operations research in the Second World War (Meredith, 2006, p. 189).
- A very significant contribution happened in 1946 when John Mauchlly and J.P. Eckert developed digital computers. Following the use of computers, G.B. Dantzig and William developed software for programming business operations in 1947.
- Linear mathematical programming was later developed in 1950 by two scientists, A. Charnes and W.W. Cooper. Since the initial digital computer was multipurpose, large scale computers were developed in 1951 by Sperry Univak to help in computation of data. Later in 1966, L. Cummings and L. Porter introduced organizational behavior whose aim was to continuously study people at workplace (Kumar, and Suresh, 2009, p. 284).
- In 1970, W. Skinner and J. Orlicky developed the incorporations of all operations in an organization into a unified strategy with common policies. In the same year, G Wright introduced the use of computers in the manufacturing industry alongside control and planning of required materials. In 1980, application of quality productivity was introduced by W.E. Deming from Japan (Kumar, and Suresh, 2009, p. 284).
- The term production management therefore was the term for since 1930s up to 2950s. Managers worldwide developed techniques for efficient manufacturing operations. From then, other scientists started studying sociology especially on human behavior in workplace while mathematical as well as computer scientists developed more advanced techniques for data analysis.
- With these new advancements, the name operations management came into be which put a lot of emphasis on expansion of the manufacturing sector. Emphasis was also put on

production in the management practices rather than the usual analyzing duties (Johnston, 1998, p. 1).

Impact of the development of operations management on business

- The development of these management operations has resulted to many positive impacts on businesses although some negative effects have been felt as well. Production in manufacturing industries has now been an organized activity where every sector of the factory has its own specialists. As a result, every sub system has an objective which it works towards achieving it. This has ensured efficiency in productivity with quality production of products.
- Since the subsections operate together with the whole of the organization, it becomes easier to get feedback from all the sections concerning the activities involved (Lewis, 2003, p. 64). This has enabled the organizations to control and make necessary adjustments on the system performance. The system of classifying productions has made it possible for manufacturers to produce a given quantity of products for specific customers at a fixed cost and time which is beneficial to both the business and the customer.
- The idea of a job shop has been useful where there is a variety of products supplied to customers but in low volumes. Detailed planning of required materials has helped in determining the essential requirements of each product and consequently, priorities of orders by customers (Evans, 2005, p. 55).
- One of the major impacts of operations management is mass production where the manufacturing system operates in large volumes in terms of inputs as well as outputs. This has mainly been made possible by the advancements of machinery where the machinery is arranged in a layout which allows automatic process of production. This has also enabled standardization of products to ensure quality maintenance.
- Mass production has been applied in many factories today especially those that involve large volume of productions within shorter periods of time. However, for mass production to be cost effective, flow of raw materials should be continuous to ease the process of controlling and planning the production operations (Paterson, 2000, p. 25).

- Mass production has also been beneficial in capacity utilization as machines are always outlined in a balanced manner. This has enabled businesses to utilize only a limited space but produce large volumes of products leading to increased profits.
- Only a few skilled operators are required to operate the machines and this has impacted businesses by reducing expenditures on salaries and wages. The cost of manufacturing a unit of products has reduced compared to production of small volumes of products. Basically, the major impacts of the development of operations management have been felt through mass production in many manufacturing businesses which is a very cost effective way of production (Mark, 2004, 340).
- Another significant impact of the development of operations management in manufacturing businesses is continuous production which is facilitated by the sequential arrangement of machines and other production equipments.
- This has made the production process faster that it was before and this has helped many manufacturing businesses meet their customers' requirements and orders in time. However, the production process is not flexible something which has made manufacturing businesses unable to accommodate changes in product manufacture especially on quantity.
- These operations developments have as well enabled businesses to provide quality products to their customers through the standardization of products. Manufacturing businesses have been enabled to satisfy the needs of their customers by producing quality products depending on the cost of production of a particular product. This way, customers get satisfied and the business obtains comfortable profits (Finch, 2006, p. 103).
- Through operations management, businesses have made use of right quantity production to prevent capital build up as well as shortage of products which would otherwise lead to lose of customers. In addition, planned production of goods has enabled many manufacturing businesses to deliver the products in time to their customer since all the involved processes are in place at all times.
- Through production planning, manufacturing businesses have been in a better position to pre-determine the production cost prior to the actual manufacturing process. This has

helped the businesses' managements to make suitable decisions after comparing the cost of production to the expected inflow.

- Planning activities have also helped business to set goals and objectives with which to work on towards quality production. The operations development has promoted organization activities in businesses which have in return played a key role in achieving the set goals and objectives by specifying the role of every individual as well as determining authority and the responsibilities involved (Chase, 1999, p. 113).
- With the increasing competition in businesses especially in manufacturing firms, operations management has impacted the global business environment. Manufacturing products (both goods and services) are now being delivered to distant locations because of the competitiveness of the products which have resulted from the advancements of the operations management.
- As a result, international manufacturing has been practiced by many businesses due to the globalization of the operations with many local manufacturing businesses producing goods specifically for the international markets rather than selling them locally (Chopra, 2006, p. 75). The chains of supplies have as well been affected with many businesses obtaining their economic inputs form all over the globe.
- Due to the ramifications involved in the manufacturing industry nowadays, specialized chains of supply for inputs have been developed to meet the ever rising demand for such services. Many businesses have now embraced the basic dimension of satisfying customers' needs considering the competitive markets (Lowson, 2002, p. 619). This has resulted to understanding the values of customers and therefore putting into considerations the specific needs and preferences of customers.
- This understanding has promoting the manufacture of products or provision of service that makes the most of the customers' needs. Another very key concern that businesses are now working on is the minimization of costs and utilization of resources with the objective of making maximum profits. Many businesses have also changed from the traditional ways of mass production to the approaches of producing goods on-demand (Jacob, 2001, p. 501).

TRANSFORMATION AND VALUE ADDED ACTIVITIES

The objective of combining resources (that is, factors of production) under controlled conditions is to transform them into goods or services having a higher (material or immaterial) value than the original inputs. The effectiveness of the use of the factors of production to produce goods and services is commonly referred to as productivity. Basically, productivity connotes a relationship of output to input such that:

$$\frac{Value\ of\ output}{Cost\ of\ input} > 1$$

This concept of value added is in contrast to the notion of engineering efficiency where energy losses within any physical system prohibit the ratio of output to input from being greater than one.

The values placed on goods or services differ with consumers. But as a large volume of output enters a competitive market, monetary amounts typically emerge as indicators of value. However, many outputs from a production system, such as employee satisfactions, social and environmental impacts, and so forth, are unique, and are difficult to value on a monetary basis. In the past, such intangible values and side effects of production decisions were often overlooked. Today we recognize the reality of these outputs and managers are forced to deal with them in terms of different individual and group value systems.

Measures of physical productivity serve as means of comparison for two or more individual units or organizations, as well as for whole industries and even nations. The resource base, population growth, ethic of the people, and existing level of technology all contribute to the economic growth rate of a nation. The productivity of the employees depends on (i) the level of training and education of the employees and (2) the substantially higher capital investment in automated production equipment.

Since organizations operate in a dynamic environment that charges over time, the inputs and outputs are best described as flows of inputs and outputs. In the physical sense, production (as a noun) results from maintaining the system flows. For a given level of inputs, improvements in the design or control of the system will increase productivity and the value of the outputs will be greater.

Production operations managers are concerned with both the technology of the transformation process and the methodology of managing the process. The technology is often unique to given industries, such as steel or paper processing, and is not the central focus of this text. However, the methodology of planning, organizing, directing, and controlling activities has a theoretical base which is common to most, or perhaps all, production activities. The development and use of this type of analytical base is the concern of this text.

TRANSFORMATION PROCESSES

A transformation process is any activity or group of activities that takes one or more inputs, transforms and adds value to them, and provides outputs for customers or clients. Where the inputs are raw materials, it is relatively easy to identify the transformation involved, as when

milk is transformed into cheese and butter. Where the inputs are information or people, the nature of the transformation may be less obvious. For example, a hospital transforms ill patients (the input) into healthy patients (the output).

Transformation processes include:

- changes in the physical characteristics of materials or customers
- changes in the location of materials, information or customers
- changes in the ownership of materials or information
- storage or accommodation of materials, information or customers
- changes in the purpose or form of information
- changes in the physiological or psychological state of customers.

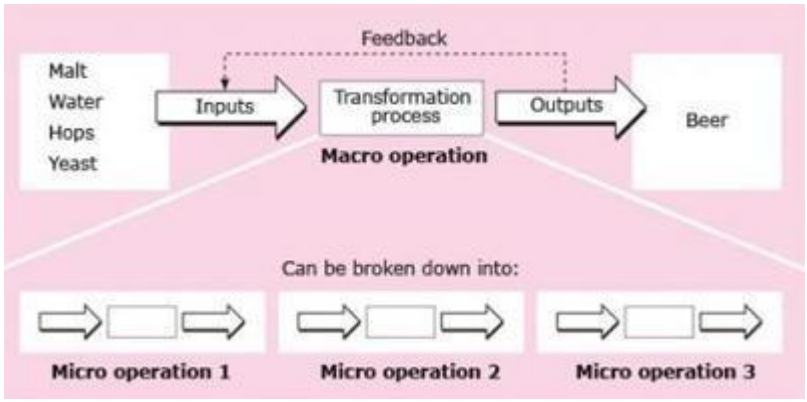
Often all three types of input – materials, information and customers – are transformed by the same organisation. For example, withdrawing money from a bank account involves information about the customer's account, materials such as cheques and currency, and the customer. Treating a patient in hospital involves not only the 'customer's' state of health, but also any materials used in treatment and information about the patient.

One useful way of categorising different types of transformation is into:

- manufacture – the physical creation of products (for example cars)
- transport – the movement of materials or customers (for example a taxi service)
- supply – change in ownership of goods (for example in retailing)
- service – the treatment of customers or the storage of materials (for example hospital wards, warehouses).

Several different transformations are usually required to produce a good or service. The overall transformation can be described as the macro operation, and the more detailed transformations within this macro operation as micro operations. For example, the macro operation in a brewery is making beer The micro operations include:

- milling the malted barley into grist
- mixing the grist with hot water to form wort
- cooling the wort and transferring it to the fermentation vessel
- adding yeast to the wort and fermenting the liquid into beer
- filtering the beer to remove the spent yeast
- decanting the beer into casks or bottles.



Nature of outputs:

1. Tangibility
2. Transportability
3. Storability (can be stored)
4. Customer contact
5. Simultaneity
6. Quality
7. A Generic Model of the Operations Strategy Process
8. A generic model of operations strategy

THE STAGES OF PRODUCTION PROCESS

1.Planning

Everything that we do, of course, needs planning. From specific activities to decisions to do something huge and have an impact on your life. In other words, it would help if you had a plan in the production stage so that the production does not lose its direction or purpose, especially in the logistic industry.

This planning process is a stage in determining several things in this process. Such as what kind of products will make, how many raw materials are used, how much cost you need, and how much labor you required to carry out production. After that, the company will also design the shape of the goods because companies need information and knowledge about the types of goods to produce, their needs, and the company's ability to carry out production activities to create a good plan.

2. Routing

Routing or determination of flow is an activity to determine and determine the sequence of activities of this process. The focus is at this stage, from the initial processing of raw materials, forming, polishing, finishing, and quality control to the distribution of manufactured goods. At this stage, you must determine the flow accurately and efficiently to run as it should and should.

3. Scheduling

Scheduling is an activity to determine and determine when production must carried out after the flow is made. In its implementation, scheduling considers the working hours of workers and the

length of each production flow. In practice, a master schedule will created at this stage and then divided or broken down into several more detailed plans.

4. Dispatching

Dispatching or orders to start production is an activity to determine and establish a process of giving orders to start production after the production schedule is set. This dispatching, it will include the results of the previous stages. They are starting from raw materials, production flow, to production time. If this stage can carried out successfully. You can confident that your process will succeed.

Production Process Characteristics

Based on the process

Based on the process, there are two production process types based on the process:

- **Direct production**: This process includes primary and secondary production. Primary production is a production activity taken directly from nature—for example, agriculture, mining, and so on. Meanwhile, the secondary process is a production activity that adds more value to an existing item—for example, wood to make houses, steel to make bridges, and so on.
- **Indirect production**: Production activities that only provide results from expertise or products in the form of services. For example, mechanical services, health services, consulting services, and others.

Based on the characteristics of the production process

Based on the characteristics of the production process, there are four types of characteristics of the production process:

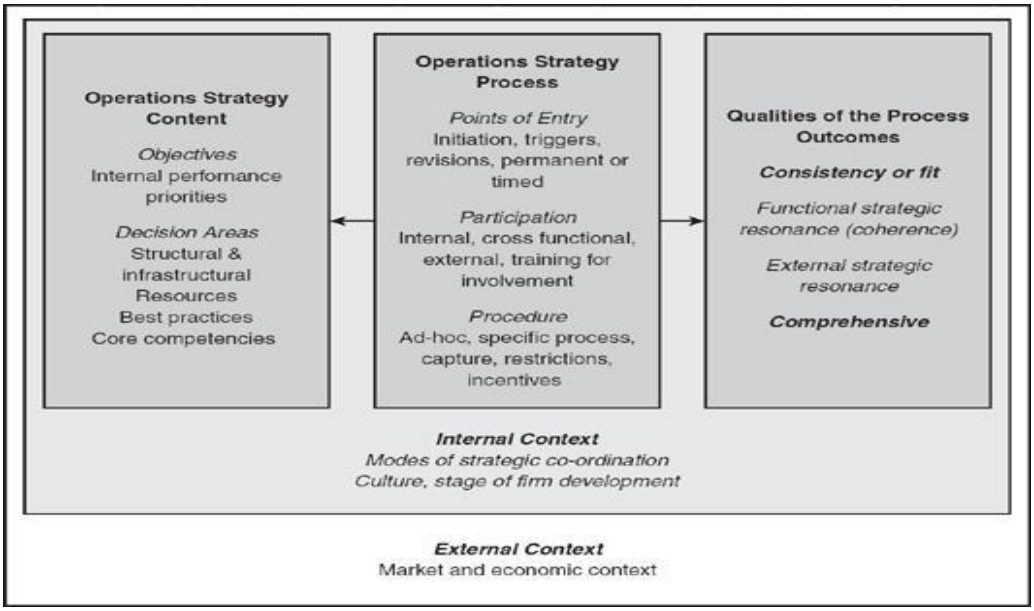
- Extractive process: Production activities by taking products directly from nature.
- Analytical process: Production activities that separate a product into more and more similar forms to the original.
- Fabrication process: The process of converting a material into several new product forms.
- Synthetic process: The process of combining several production materials into a product form. Synthetic procedures are also often referred to as assembly processes.

Based on the production period

Based on the production period, there are two types of characteristics of the production process:

- Continuous production: Production that uses various facilities to create products continuously. Meanwhile, the nature of the product is only a few types and produced on a large scale without affected by season or weather conditions, and time.
- Intermittent production: Production that does not run all the time. Usually affected by changing seasons, orders, and various other factors.

OPERATIONS STRATEGY



What Is Operations Strategy?

Operations strategy is a guiding principle used to plan, analyze, and execute a company's operations. Businesses use operations strategies to identify and implement cost-effective processes for creating and distributing products and services. An operations strategy supports a company's overall business strategy in order to maximize profits.

What Are Operations Resources and Market Requirements?

Operations resources include a wide variety of company resources like equipment, people, facilities, vendors, and technology. Operations managers oversee the scope of a company's operations resources and monitor how those resources facilitate products or services.

Market requirements refer to business goals and operational plans for how to meet market needs. Market requirements are an essential part of any operations strategy as they determine the cost, quality, and lead time of a product or service in order to meet customer expectations.

5 Key Elements of an Operations Strategy

There are a few key elements that go into a company's operations strategy.

1. **Production system**: An organization's production system determines the short-term and long-term planning for how resources are turned into marketable products and services. A

comprehensive production system includes clear workflows, quality control benchmarks, and supply chain management strategies.

2. **Facilities**: A company's operational capabilities are influenced by the size and number of production facilities. To function properly, specific facilities require achievable production goals, clear safety procedures, and inventory management systems.
3. **Product or service**: One of the most important elements of any operations strategy is the quality management of a product or service. Businesses analyze the lifecycle of their products and services in order to predict market trends, adjust their product or service, and allocate resources to new service development and product development.
4. **Technology**: Operations strategy increasingly depends on new technological developments like machine learning, production line automation, real-time metrics, and market forecasting tools.
5. **Resources**: A comprehensive overall strategy for operations takes into account the total operations resources available to an organization, including locational, mechanical, and human resources.

Types of Operations Strategies

Businesses employ different types of operations strategies based on their specific market needs.

1. **Core competency strategies**: Core competency operations strategies revolve around the main strengths of a company's business model. By identifying the best core business processes within an organization, core competency operations strategies focus on leveraging existing strengths to maximize profitability.
2. **Corporate strategies**: This type of operations strategy adheres to a company's mission statement and aligns itself to a larger corporate strategy. Businesses using this type of operations strategy develop production initiatives, key performance indicators (KPIs), and decision-making processes based on an overall strategic plan determined by company leaders and stakeholders.
3. **Competitive strategies**: Companies using this type of strategy develop their operations processes in order to distinguish their product or service from competitors. By identifying competitive priorities within a specific economy, businesses can change their operations strategy to move toward a competitive advantage, whether that's a higher-quality product or a faster lead time during production.
4. **Product or service strategies**: This type of operations strategy revolves around the quality control of existing products or services as well as the development of new products and services. Businesses using this model often determine their operations strategies based on the research and ideas from product managers.
5. **Customer-driven strategies**: Organizations using customer-driven strategies make operations decisions based on the customer experience. This type of operations strategy aligns with sales and marketing strategies to manage and fulfill customer expectation

GOODS AND SERVICES

Goods and services are an essential part of an economy, and these two terms are used in most of the important economic discussions.

There are many products that a consumer purchases in order to fulfill their certain requirements. These products can be either in the form of goods or services.

Goods are tangible, as in these have a physical presence and they can be touched, while services are intangible in nature.

The purpose of both goods and services is to provide utility and satisfaction to the consumer.

Goods Meaning

The meaning of goods can be expressed in terms of economics, as any item that provides utility and fulfills the needs of the consumer.

Goods can be classified as durable and non-durable based on their durability. Durable goods last for a long time while non-durable goods perish sooner than durable goods.

Goods involve transfer of ownership from the seller once it is purchased by the consumer (buyer). There is a certain time period that is required for the production of goods.

Goods due to their tangible nature have a proper structure, size and shape. They can be produced as per the market demand.

Services Meaning

Services are the intangible and non physical part of the economy that cannot be touched. They are perishable in nature as they need to be provided at a moment when requested by the consumer.

Service lacks a physical identity and cannot be owned, it can only be utilised. For e.g, when having dinner at a restaurant you can avail the concierge services but you do not own the restaurant.

In other words, there is no transfer of ownership in services and unlike goods, services cannot be stored and utilised later. Also, services cannot be distinguished from the service provider.

The following points of difference between services and goods can be discussed.

Basis of Comparison	**Goods**	**Services**
Nature	Tangible	Intangible
Transfer of	Possible	Not Possible

Ownership		
Separable	Goods can be separated from the seller	Services cannot be separated from the service provider
Storage	Goods can be stored	Services cannot be stored
Perishable	Not all goods are perishable	Services are perishable
Production and Consumption	Goods have a significant time gap between production and consumption	Services are produced and consumed together

What Is Operations Management Perspective?

The theory of operations management describes the practices companies use to increase efficiency in production by using the right tools. The goal of operations management is to ensure that the production process and business operations are as efficient as possible.

Productivity Frameworks And Tools For Effective Management

When you add the long list of queries around productivity tips, productivity apps, productivity planners, and other forms of definitions around the term, we're ranking over 300,000 total searches across the board.

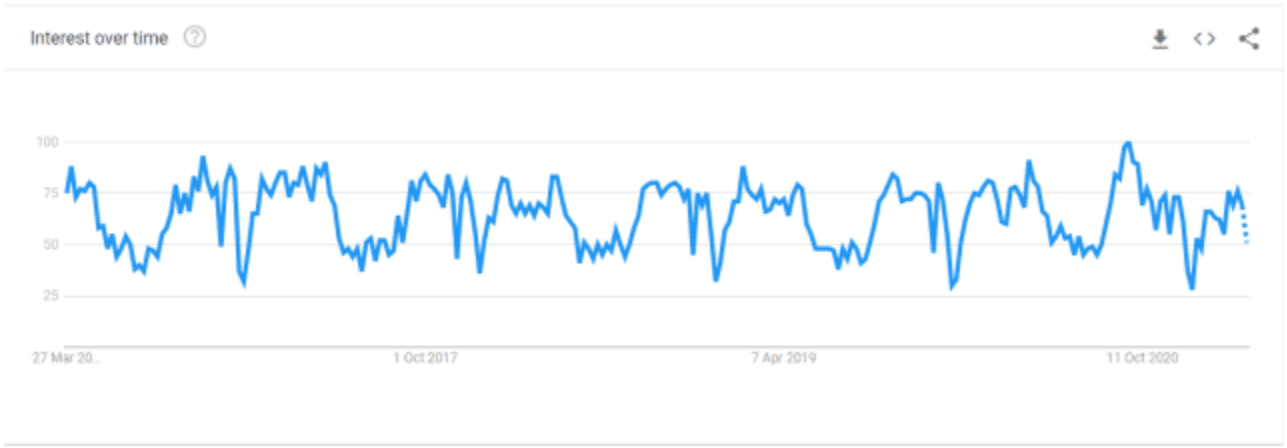
We are all eager to fight procrastination and maximize our time. Best-case scenario, deliver more in less time, reduce stress and the tedious backlog at the end of the day, and get better at everything we do: professionally and personally.

Productivity Trends

But here's a fun fact for you.

Productivity has always been a chore. Humankind has been dealing with maximizing efficiency while increasing impact for centuries.

We can validate this hypothesis by looking into Google Trends. But there's something else that's even more intriguing in this 5-year chart of users looking up productivity online:



productivity search trends since 2016

The percentage of users interested in productivity hasn't decreased or increased drastically over the past 5 years. But have you noticed these drops in searches that Google has conveniently remarked here?

The lowest 5 drops are all clocked between Dec 20 and Dec 26. Christmas and Hanukkah inevitably shift our focus to family, combined with the holidays at the end of the calendar year.

And apart from this gap, there are certain months where productivity searches are way off!

Summertime, of course. **June and July mark the lowest interest in productivity around the year** (with the exception of Christmas). There's a notable decrease starting late in May and growing back early in August.

Productivity matters the most when school and work are back on track and students and employees together hunt for the Holy Grail in productivity. Acing that class or earning this Q4 bonus are strong motivating factors for getting the most out of your life — and here's what we will cover in this productivity guide.

This is a compilation of my own strategies and tools that I used to perform at my best, and techniques I've learned from industry leaders and productivity trainers over the past 15 years.

1. The Decision Tree

Executives, managers, freelancers, consultants, parents: We all have to make hundreds of decisions every single day.

Anything from "*Where can I find an optimal parking spot*" to "*How to maximize these 30 minutes before the next meeting*" to "*Is this prospect aligned with our company culture.*"

This is unbearable unless you have a strong foundation of values and goals.

Whenever you have to pick between "*should I invest an hour in my personal brand for the long-term*" or "*call 5 more prospects from the list*", you need a predefined framework that holds the answer to this very question. One such framework is the Decision Tree.

While this exercise takes a while to complete, it's a must-do.

You can start by building a comprehensive tree of what truly matters to you. Every day, you will face contradictory questions and deal with more than you can handle. Learning how to cope is all reliant on your prioritization queue which sits right under your tree of values.

- You always have to pick your kid up from school no matter what. This is an activity that sits on top of your tree.
- If personal branding is really important to you, make it a priority. Don't make excuses with the "yet another lead" and just block 45 min. of your time daily on working on your brand.

- Is your cooking class really that important? If it truly charges you greatly, then make it a priority. But if it jeopardizes your work and can lead to more serious consequences after, consider if you'd skip classes every time an important request comes in.

  These simple examples lead to the core answers. "Family vs. work", "Time vs. professional development", "Higher revenue vs. culture development", "Tons of cash from a political party vs. less stress and no disappointment from certain team members."

  Decision trees can help you become highly productive by guiding you in making decisions swiftly.

  Basically, a decision tree is like a diagram that shows how one decision can possibly lead to different scenarios which would then require another decision. You increase the level of your productivity since the decision tree simplifies and predicts the decision-making process for you.

  You still need to revise your core framework every 6 months or so. But between your "sanity check" self-meetings, you accept these goals as axioms and base your decisions solely on your foundational paradigm of what you firmly believe in and believe would define you as your best self.

  Making time is a matter of energy management and motivation.

2. Eat the Frog

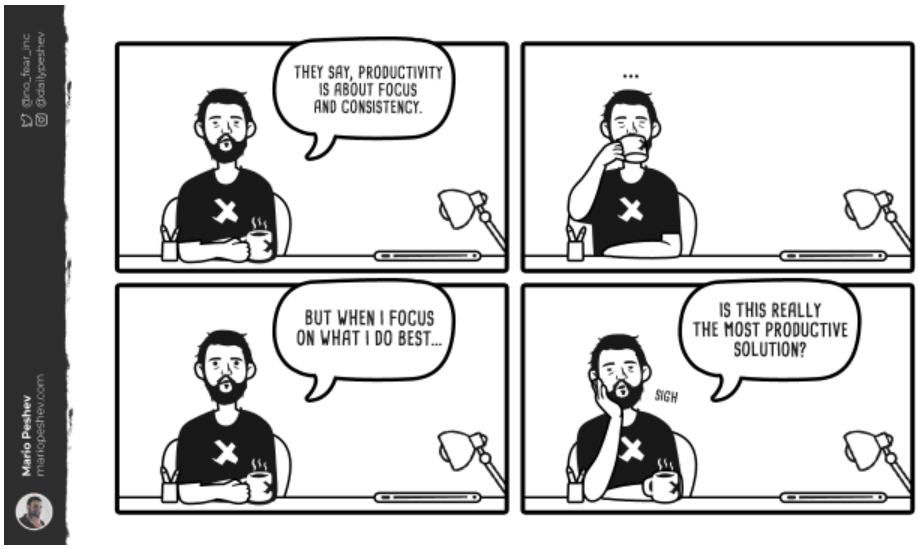
Do you always have a hard time managing your time and sticking to a productivity system with several interruptions to deal with? Does your to-do list end up overwhelming you, instead of organizing your tasks for you?

Eat the Frog is the productivity framework that encourages you to identify the biggest and most important task for the day and focus on it before anything else.

You must work on this task first thing in the morning or whenever you start your work so you will not have a chance to put it off at a later time.

This technique fights off procrastination and targets the 20% of your daily tasks that are often the most important.

Here's a great read on this matter by Brian Tracy: Eat That Frog!: 21 Great Ways to Stop Procrastinating and Get More Done in Less Time



3. The Eisenhower Matrix

Not all tasks are equal. They are often categorized according to the degree of their urgency or importance. Often, people are confused between what is “urgent” and what is “important”.

The Eisenhower Matrix helps you make a clear distinction among tasks. Also called the Urgent-Important Matrix, this technique fits those who:

- lack the energy to work on long-term goals
- busy with tasks with minimal impact

It provides a visual method of time management by splitting tasks into four quadrants. Each quadrant follows a specific order of completion so each quadrant is labelled with numbers one to four and the following action points: do, decide, delegate or delete.

- Do: the most important and urgent tasks belong under this box
- Decide: important but not urgent tasks must be scheduled and worked on under this box
- Delegate: urgent but not important tasks must be delegated. They are often menial tasks that can be taken care of by others
- Delete: these are tasks that are absolutely not important and not urgent. You may still do them, but only when you have no other tasks to do

4. Time Blocking

“I don’t have time” is the number one excuse for procrastination.

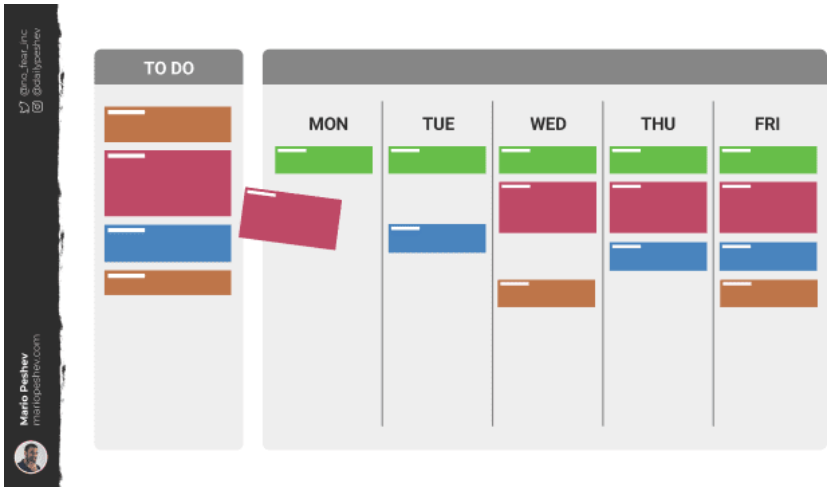
Has anyone been granted more than 168 hours a week?

Making time is a matter of energy management and motivation.

If you are failing to make time for what matters the most to you, then you are either failing to manage your energy effectively or don't care about this enough.

If surfing is more important than your job, either find a job near the ocean where you can surf (or teach) or find a way to land a remote job that pays "enough" for survival so that surfing is top of mind.

Otherwise, it's just a hobby that falls under the "*nice to have*" category.



Time Blocking is a productivity framework that is suitable for those who are swamped for the most part of the day with several interruptions and instead of working on important tasks, they end up being reactive to these interruptions.

You can dedicate blocks of your time to specific tasks so others cannot easily steal your time. Although this appears to be a chore at first, you will be able to appreciate how you actually get more time focusing on your high-level priorities.

5. The Pomodoro Technique

The Pomodoro Technique is a powerful framework for employees who work on long, complex tasks continuously. I tried it for a few months back in my software engineering days when meetings, sales calls, and regular emergencies weren't all too common.

Here's how Pomodoro works in practice:

- Pick a new task at hand that you need to complete
- Set a 25-minute alarm for non-interrupted time to work
- After the work sprint, take a 5-minute break
- Every 4 pomodoros, take a 20 to 30-minute break before the coming sprint.

There are online apps that let you accomplish that (and even physical Pomodoro clocks that do the counting for you).

As you turn your phone and messengers off and truly focus on the job (being pressed by time), the odds of accomplishing more in less time increase significantly.

6. Getting Things Done

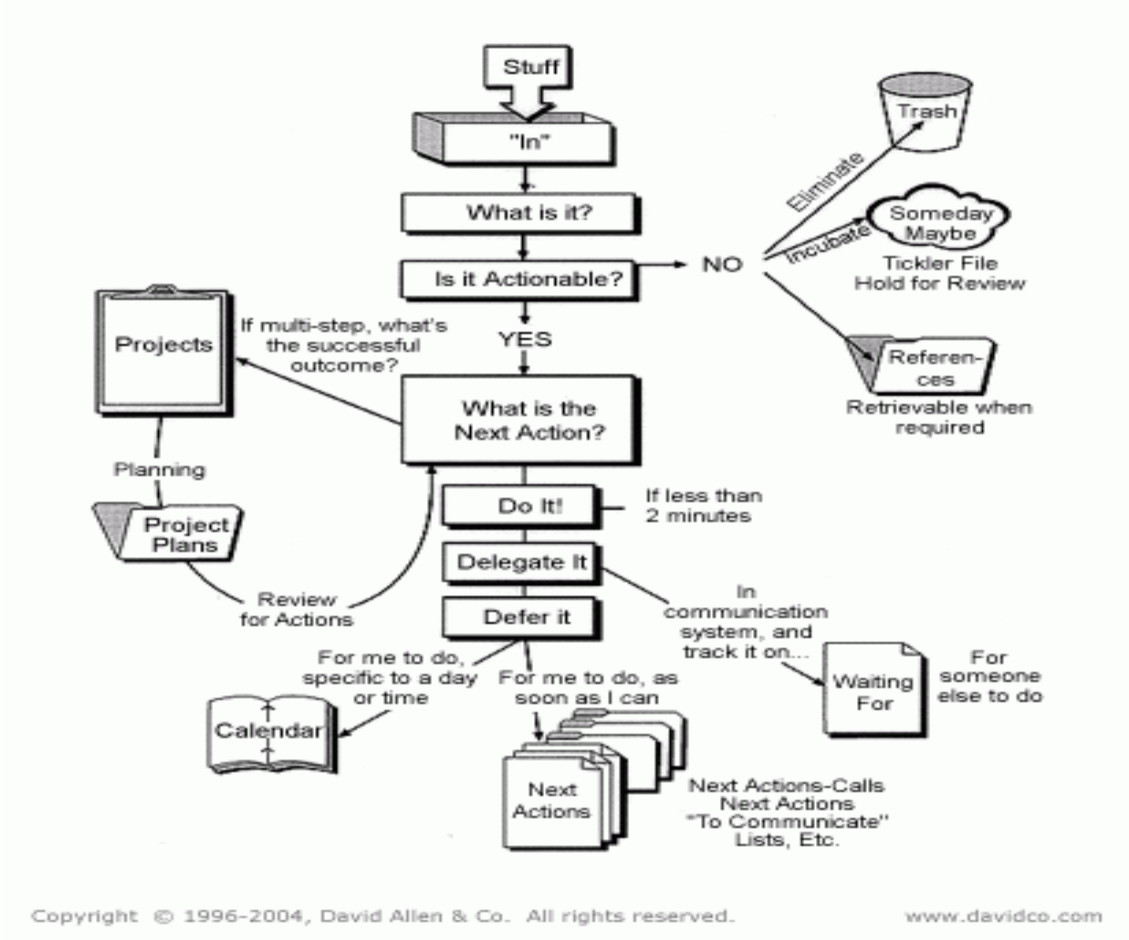
"Getting Things Done" is one of the older productivity methodologies originally announced by David Allen in 2001.

The productivity framework revolves around a number of activities on effective task management, resource allocation, and grouping assignments in an organized manner.

This management technique is organized around five different lists you manage:

- "In" (brain dump)
- Next actions (todo)
- Waiting for (blockers)
- Projects (larger activities)
- Some day (future)

Going through the incoming tasks follows a specific workflow in order to organize tasks properly (as seen in D&E's chart):



GTD is more complex to implement, but if you're looking for a single system to rule 'em all, investing some time in studying the system can yield awesome benefits.

7. The 1-3-5 List

The 1-3-5 list is one of my favorite techniques that I use when traveling or during the intense events season.

What it boils down to is a daily agenda that includes:

- 1 priority task to be done "no matter what"
- 3 doable activities you should do
- 5 low-effort, quick wins for the day

Instead of cluttering your backlog with everything and anything, pick a few items and assign them for the day. One step at a time with a clear roadmap ahead.

With less than 10 daily tasks to handle, constant interruptions could be prevented with the right preparation. This simplifies your weekly planning as well – delegating low priority requirements and optimizing your management backlog for the coming week will take no longer than 2 hours.

Alex Cavoulacos, the author of The New Rules of Work and a Founder of The Muse, is a proponent of the 1-3-5 method:

For example, when a surprise presentation falls on your lap, try: “Sure, I can get that to you by 3 PM, but the Q1 reports won’t be ready until tomorrow then, since I’d scheduled to work on that today.”

Cavoulacos also advises using your calendar as a to-do list. Completing the highest priority task before lunch can result in a notable motivation and a boost for closing the rest of the tasks before the end of the day.

A stand-alone app named “135 List” is the go-to companion for your smartphone or a browser if you want to dive into the philosophy of the core team.

8. Done-Done

The Done-Done technique is one particular lesson I’ve learned from Chris Lema.

In most cases, you have to clarify whether a task is really done or complete.

There are times when “done” can have several variations. For instance, try asking your teammates if an assignment has already been done or completed and you would get different responses that may have a connotation that a task is done, but is it really “Done-Done”?

You would be surprised how most tasks need more polishing although they are close to getting done. Make sure you clarify which part of a task is really done and which aspects need more work.

This productivity framework is also something you can incorporate in your management principles. You and your team will be able to develop appreciation for every detail especially you will be able to save time from having to do more reviews than necessary.

9. Interruption Science

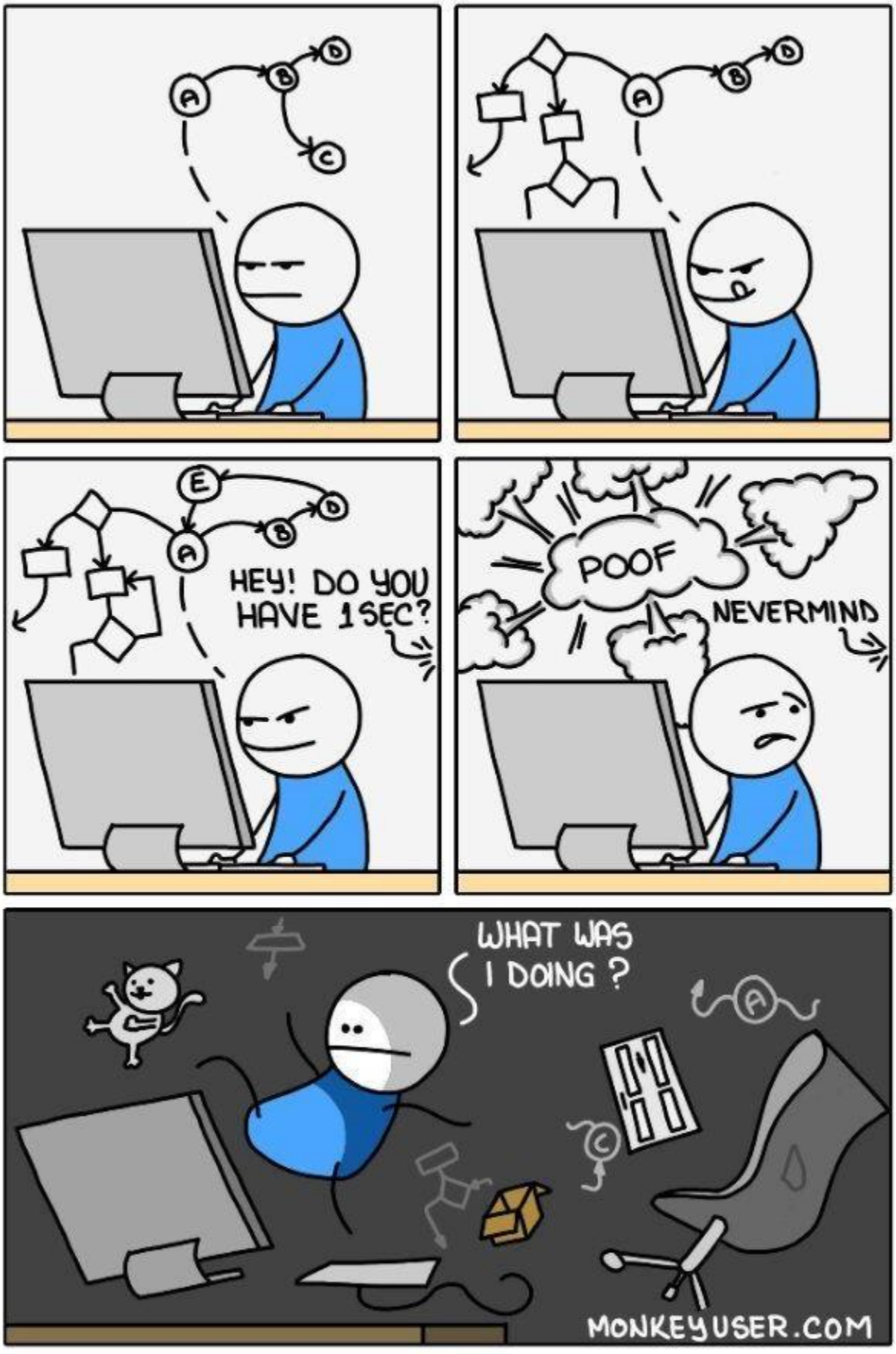
After crossing off several techniques, let’s focus on what matters: **focus itself**.

Interruption science is the study of human performance including a myriad of factors affecting productivity.

Especially among office workers and important industry professionals (like doctors or prosecutors), implementing effective techniques with conducting critical activities with limited disruptions may be a life-or-death case.

With the evolution of push notifications, instant messengers, random robocalls, workers often receive over a hundred interruptions throughout the day. And more complex scenarios may require over half an hour in returning back to your focused state.

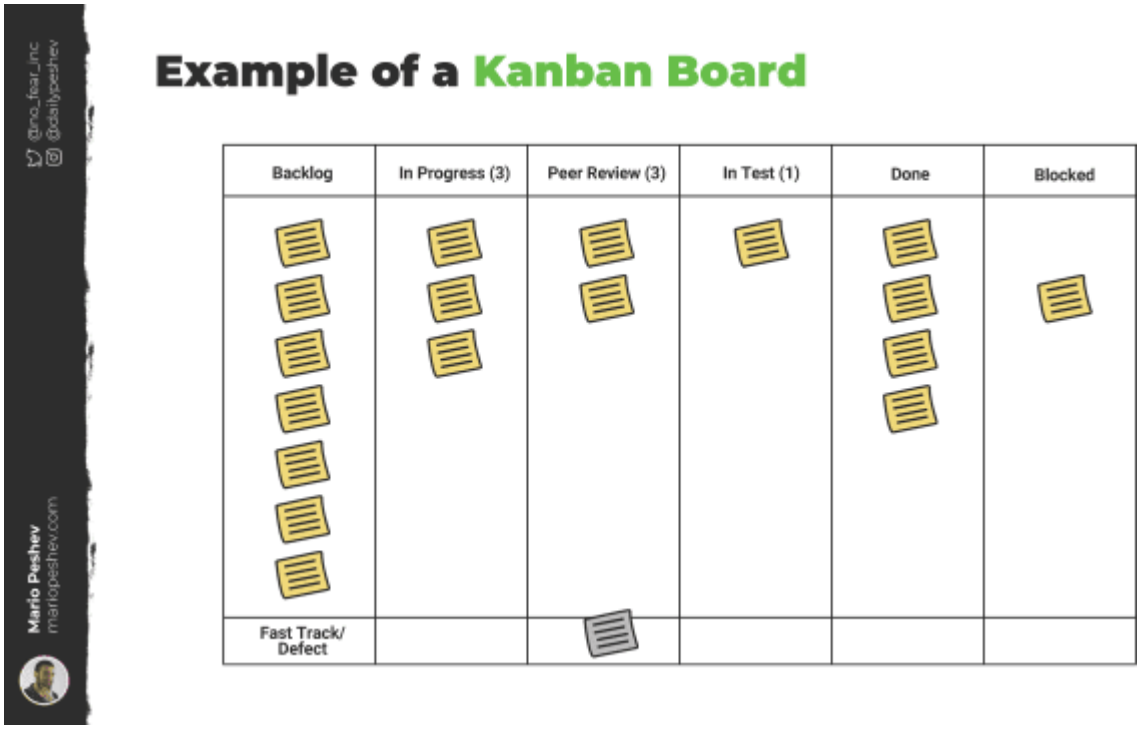
FOCUS


A
B
C
D
E
HEY! DO YOU HAVE 1 SEC?
POOF
NEVERMIND
WHAT WAS I DOING ?
MONKEYUSER.COM

10. Kanban

Some projects can seem too complex until you break them down into manageable tasks. If you would like to ensure transparency throughout the process, you can use the framework called Kanban.

Kanban helps you become productive by visualizing your work and emphasizing efficiency. Originally a Japanese concept, Kanban also translates to a billboard or a signboard.



Most project management leads incorporate Kanban when implementing the agile project management methodology. How does this work?

Specific work items must be displayed on a kanban board. Then, responsible team members can help you determine which of your work can be prioritized while also monitoring the progress of each item.

11. Don’t Break The Chain

Jerry Seinfeld, the infamous actor and standup comedian, has shared his alternative calendar system that helps him progress – both professionally and personally – one step at a time.

The secret to Seinfeld’s recipe is in projecting the bigger picture and embracing the time it takes to achieve results. Unlike the 1-3-5 method, Don’t Break the Chain relies on a gamified experience whenever there’s a major obstacle to overcome.

For example, you are determined to improve your public speaking skills in order to pitch your new product at TechCrunch Disrupt. There are 6 months to go and tons of fine-tuning ahead. Working on your body language and posture, clear pronunciation, coming up with powerful stories, and training your voice are just a small subset of the activities you are about to excel at.

Writing these down into a bloated list of tasks simply won't work.

Seinfield – being your virtual coach – will hand you a calendar and tick today's date. Your mission is to go through your draft pitch. Take some notes and mark it down on your calendar.

Repeat the same talk tomorrow, then the day after. Keep accumulating the track record of exercises on a daily basis. It's all about incremental improvement and practice. Over time, your consecutive list of pitches will serve as a spiritual source forcing you to move forward.

Matt Mullenweg, co-founder of WordPress and the CEO of Automattic, shared his tips when it comes to chores that most people try to avoid at all costs over an interview for Tim Ferriss.

"Just before I got in the shower, I did 1 push-up.", says Mullenweg. "And no matter how late are you running, no matter what's going on in the world, you can't argue against doing one push-up. Like, come on, there is no excuse. So, I often find I just need to like, get over that initial hump, with something that's almost embarrassingly small."

12. Bucket Lists

This is a technique I learned from one of my assistants (thanks Tai).

For context, all of my content online is written or recorded by me. However, repurposing content, aggregating Quora answers which get published on the blog, submitting Instagram captions gathered from my articles, editing videos, fixing subtitles (and more) are managed by my secret MBOT team working closely with me.

Maintaining dozens of recurring initiatives means that I have to bounce between work assignments frequently, and the volume of work is overwhelming.

So what my team established as a process is "bucket lists".

A bucket list represents the volume of X every assignment has to maintain. For instance:

- 40 Quora questions I can jump in and respond to
- 8 blog post drafts to review before scheduling here
- 14 Instagram images or graphics going live on @dailypeshev

- 10 video snippets repurposed from my longer-form videos
- 15 content topic ideas gathered from tweet replies and LinkedIn comments
- 5 slide deck pitches based on my existing blog articles

By establishing this workflow, my team can effectively manage more initiatives per person on a weekly/monthly basis. Once a bucket is full, they hop on and start to maintain another bucket.

And when I have a spare couple of hours, I pick two or three buckets, spend some time rejecting headlines, answering questions, approving images and videos, and clean up some of the existing entries available to review. Buckets (almost) never deplete fully, so I have plenty to work with, and my team makes a note and prioritize tasks I've already worked on, making sure they're back at full capacity soon enough.

Managing buckets sets expectations for you and your team and enables you to do more with fewer resources without tedious repetition.

Each Task Should Solve a Single Small Problem

Software development principles present the rule of "cohesion" – every function or a class should solve a single problem, a clearly defined one, with a well-focused purpose.

The more convoluted a problem is, the harder it is to design a solution, answer all blocking questions, and ensure you avoid regressions (and unnecessary back-and-forth).

A common mistake in managing your daily backlog (even if you employ the 1-3-5 list or GTD) is working on a vague set of tasks consuming your brain capacity and wasting precious time.

For instance, if you need to write an article and it's a daily task of yours, consider breaking it down to smaller, individual pieces, clearly independent from one another and designed in the corresponding order, i.e.:

- Research 5 topic titles to work with
- Pick a topic most closely related to your priorities
- Design an outline with at least 6 headlines
- Research 4 statistics to be quoted in the piece
- Write the headline and the summary of the article
- Fill out the rest of the content
- Supplement with images
- Assign to Jane for an editorial review

This seemingly simple task suddenly morphed into easily digestible, but clearly defined goals. Even if you're tired or moderately distracted at the time, working on clear assignments is a lot easier, progress is achieved quickly, work can be interrupted in the middle of the process, and longer assignments can even be distributed across several days.

Sticking to the rule of "task cohesion" will unblock you and set clear expectations toward the actual volume of work you have to undertake.

Annual Resolutions

The most popular resolutions out there commence on New Year's Eve.

During the retrospection of the past year, people all around the world decide to engage in new activities, enroll in a class, purchase a gym membership or simply task themselves to accomplish more than they could handle.

Enforcing reality checks and using some of the productivity frameworks reviewed here can help align expectations and deliver more than what you usually do. But aside from the mechanics of the exercise, it's important to follow some common sense advice as well:

- Be realistic when defining your list of resolutions
- Don't limit your planning to a singular Jan 1st effort
- Prepare a well-defined plan that reveals the full context of the plan
- Discuss the plan ahead with friends, colleagues, family
- Design an effective way to track progress
- Gamify the experience and reward yourself
- Establish realistic time frames and reasonable goals

- Clear out all and any obstacles that could hypothetically get in the way
- Don’t give up once you’re committed to the challenge

Your Energy Is The Most Important Asset

Do you know what makes entrepreneurs so effective at what they do?

No, it’s not *just* clocking 80-hour workweeks.

Entrepreneurs have the luxury to juggle with dozens of activities on a daily basis. While multitasking is known to hurt productivity, switching between different action items is a healthy exercise for your brain.

Spending 8 hours on preparing a complex spreadsheet is tiresome. But hopping between a strategy meeting and a sales call after reviewing the financial forecast and before you coordinate the product roadmap leads to an effective workflow that fully removes procrastination as an obstacle.

Diverse activities, scheduled appointments, tough deadlines are inevitably squeezing efficiency out of a leader.

More importantly, it’s an external factor that contributes to maintaining energy levels.

Energy is your biggest asset by far. If you are more productive in the morning, make the most out of this time. Arrive early at the office or prepare some tasks ahead of time while sipping your coffee. Night owls can arrange their agenda before wrapping up for the night and schedule all energy-intensive activities late in the evening.

Instead of looking for another hour to spare and catch up, carefully monitor and maintain your energy for maximum efficiency. Keep in mind that eating habits, sleep, and focused time greatly contribute to this equation.

Productivity As A Habit

Beginner managers or entrepreneurs often look for workarounds when it comes to squeezing some efficiency on top of their workday.

There are no shortcuts to success. But productivity frameworks and tools can enable you to accomplish more in less time, thus maximizing your time, investing additional energy in the long-term strategy.

More importantly, productivity is a trainable skill. You have to practice it continuously. Refine your processes. Optimize your scheduling chops.

And as your business grows (along with your responsibilities), always keep an eye on new techniques that could come in handy at the right time.

WORLD CLASS MANUFACTURING

Introduction

Manufacturing has evolved considerably since the advent of industrial revolution. In current global and competitive age, it is very important for organization to have manufacturing practice which is lean, efficient, cost-effective and flexible.

World class manufacturing is a collection of concepts, which set standard for production and manufacturing for another organization to follow. Japanese manufacturing is credited with pioneer in concept of world-class manufacturing. World class manufacturing was introduced in the automobile, electronic and steel industry.

World class manufacturing is a process driven approach where various techniques and philosophy are used in one combination or other.

Some of the techniques are as follows:

- Make to order
- Streamlined Flow
- Smaller lot sizes
- Collection of parts
- Doing it right first time
- Cellular or group manufacturing
- Total preventive maintenance
- Quick replacement
- Zero Defects
- Just in Time
- Increased consistency
- Higher employee involvement
- Cross Functional Teams
- Multi-Skilled employees
- Visual Signaling
- Statistical process control

Idea of using above techniques is to focus on operational efficiency, reducing wastage and creating cost efficient organization. This leads to creation of high-productivity organization, which used concurrent production techniques rather than sequential production method.

World Class Manufacturers

World class manufacturers tend to implement best practices and also invent new practices as to stay above the rest in the manufacturing sector. The main parameters which determine world-class manufacturers are quality, cost effective, flexibility and innovation.

World class manufacturers implement robust control techniques but there are five steps, which will make the system efficient. These five steps are as follows:

- **Reduction of set up time and in tuning of machinery:** It is important that organizations are able to cut back time in setting up machinery and also tune machinery before production.
- **Cellular Manufacturing:** It is important that production processes are divided into according to its nature, with similar nature combined together.
- **Reduce WIP material:** It is normal tendency of manufacturing organization to maintain high levels of WIP material. Increased WIP leads to more cost and decreased WIP induces more focus on production and fast movement of goods.
- **Postpone product mutation:** For to achieve a higher degree of customization many changes are made to final product. However, it is important that mutation conceived for the design stage implement only after final operation.
- **Removal the trivial many and focus on vital few:** It is important for organization to focus on production of products which are lined with forecast demand as to match customer expectation.

Principles of World Class Manufacturing

There are three main principles, which drive world-class manufacturing.

- Implementation of just in time and lean management leads to reduction in wastage thereby reduction in cost.
- Implementation of total quality management leads to reduction of defects and encourages zero tolerance towards defects.
- Implementation of total preventive maintenance leads to any stoppage of production through mechanical failure.

Aspects of World Class Manufacturing

The main aspects of the world-class manufacturing are as follows:

- Industrial culture area
- Market/client area
- Product development area
- Operations area
- E-Performance area

World Class Manufacturing is a continuous improvement system. It is a way of thinking which was made to bring organization manufacturing on a worldwide level. Learn how to implement it into your business!

We can say that World Class Manufacturing is a Continuous Improvement System. World Class Manufacturing is a set of concepts, policies, techniques, and principles for operating and managing a manufacturing company.

World Class Manufacturing is a management concept, which can be translated as production on a global level philosophy of WCM in the manufacturing plant has decreased misfortunes and improved the quality of the items. World Class Manufacturing is an administration idea, which can be interpreted as a creation on a worldwide level. It is a way of thinking which was made to accomplish brings about organizations on a worldwide level.

The fundamental principles of the WCM are:

- Reduce wastage and misfortunes
- Improve the standards and techniques
- Involve all representatives during the time spent consistent improvement

The keynote which goes with this procedure is: *"No procedure is flawless. There is consistently a place for improvement"*.

Moreover, the World Class Manufacturing depends on the standards of Kaizen (Continuous Improvement), Total Quality Management and Lean Manufacturing. The utilization of frameworks required to accomplish the degree of World Class Manufacturing is utilized by most organizations that have the **aspiration to accomplish the degree of industry or market pioneer or to have a position 10 % of the best.**

It is really important for companies and managers to adopt the manufacturing processes into their work, not only that it will help them, but it will also provide lead time, quality, cost, customer service, and flexibility. With the end goal for organizations to contend on the world stage, organizations should concentrate on creating quality items and administrations, conveying on schedule, and running activities at the most minimal quality conceivable.

To accomplish world-class status, organizations must change methods and ideas to enhance their procedures. This will prompt reproducing associations with providers, buyers, makers, and clients.

World Class Manufacturing is a process-driven approach that generally involves implementing the following philosophies and techniques:

- Make-to-order
- Streamlined flow
- Small lot sizes
- Families of parts
- Doing it right the first time
- Cellular manufacturing
- Total preventive maintenance
- Quick changeover
- Zero Defects
- Just-in-time production
- Variability reduction
- Employee involvement
- Cross-functional teams (quality control circles)
- Multi-skilled employees
- Visual signals
- Statistical process control

Important rules if you implement World Class Manufacturing system in your work:

- Voice of the customer is heard to the last level in the organization
- People are the driving force of change
- Motivating environment
- All faults are visible
- Continuous improvement through loss eradication
- No type of waste is accepted
- Methods for improvements are applied strictly

There are seven keys to becoming a world-class manufacturer:

1. Accelerate time-to-market
2. Reduce lead times
3. Simplify outsourcing processes
4. Manage the global enterprise
5. Business performance!
6. Overtop customer expectations

7. Cut operations costs

The organization, which executes WCM is as yet changing, to accomplish the status of a world pioneer, looks for open doors for steady enhancements in key regions for intensity.

World Class Manufacturing Strategy

- Develop People
- Training
- Coaching
- Empowering individuals for self learn
- Develop Processes
- Standardize and adjust techniques and instruments
- Transfer WCM information sharing accepted procedures
- Develop Organization
- Promote WCM individuals joining
- Keep WCM people group alive

History

Globalization offers one of a kind test to assembling firms since it showed up. Economies of whole countries will choose how well assembling and activities are overseen (regardless of whether it is improved or declined). Organizations began to offering clients better an incentive by improving item quality and accomplishing higher efficiency.

During the industrial revolution, a progression of modern developments upset how work was performed. Eli Whitney (1790s) presented "exchangeable parts" . After that, F.W.Taylor recognized "logical administration" . Afterward, Henry Ford applied logical administration which named "large scale manufacturing". Mass assembling was the primary presentation of taking generation on a 'more significant level'. It commanded producing worldwide up to 1960s.

Benefactors were:

1. Abraham Maslow
2. George Dantzig and Remington Rand
3. Elton Mayo

Japanese Manufactures utilized ideas of **Just in time, Lean Production, Quality, and Flexibility.** Discussing Japan, this nation assumed the lead job even in creating World Class Management, about which you will adapt later in this article.

Worldwide challenge has caused central changes in the focused condition of assembling businesses. Firms must create vital destinations which, upon accomplishment, bring about an upper hand in the commercial center. Nonetheless, for practically all assembling ventures, expanded profitability and better by and large proficiency of the creation line are the most significant objectives.

The idea of World Class Manufacturing (WCM) was created by Richard J. Schonberger (during the 80s) who gathered a few cases, encounters and declarations of organizations that had left on the way of persistent "Kaizen" improvement for greatness underway, attempting to give an efficient origination to the different practices and systems inspected.

WCM was created by Fiat and collaborating firms in 2005. Hajime Yamashina, Professor Emeritus at Kyoto Universality in Japan, assumed a key job.

What is TPM?

Total Productive Maintenance

Everything started in the 1970s in Japan. Created by JIPM. Total Productive Maintenance represents a system accentuating total Care (Maintaining) of machines

The generous increment in systems can be connected to some extent to the developing impact of the assembling ways of thinking and the monetary achievement of Japanese producers from the 1960s onwards. In 1986, the term has developed impressively. Schomberger created one of the most important definitions. He pointed out the term "World Class Manufacturing" to cover the many techniques and technologies designed to enable a company to match its best competitors.

WCM Model by Schonberger includes:

- Just in time (JIT)
- Total Productive Maintenance (TPM)
- Simplicity
- Total quality management (TQM)
- Employee Involvement

Even though these techniques have been known for a long time, Schonberger integrated and merged a perfectly integrated and flexible system that provides products of high quality and company competitiveness.

Stage 1: Minimize assembling's negative potential: "inside unbiased"— producing is kept adaptable and receptive.

Stage 2: Achieve equality with contenders: "remotely unbiased"— capital speculation is the essential method for making up for lost time with rivalry or accomplishing a focused edge.

Stage 3: Provide valid help to the business technique: "inside steady"— an assembling methodology is planned and sought after; longer-term producing advancements and patterns are tended to methodically.

Stage 4: Pursue an assembling based upper hand: "remotely steady"— producing is included in advance insignificant procedure talks with an equivalent seat at the table with deals, advertising, designing and account.

Talking about manufacturing and processes in general, we must not forget to mention losses that are part of the whole manufacturing process, in every company.

What are losses?

Something we do that doesn't add any additional value to the final customer's product. It is often perceived as inevitable. Losses mostly can be eliminated, for the most parts of production.

WHAT ARE Manufacturing Performance losses:

This is when a Line unexpectedly stops while it is intended to be in production under a launched Production Order. These losses are mostly the responsibility of manufacturing, but there can be exceptions.

WHAT ARE Process Driven losses:

These occur when a Line is intentionally stopped to complete certain activities on a machine or Line. While these activities are being carried out, the Line is not able to produce. These losses have a shared responsibility (e.g. manufacturing, planning, and engineering are all functions which may share the responsibility)

Important terms related to World Class Manufacturing

1. **Cellular manufacturing**

The concept of cellular manufacturing is an important component for both JIT manufacturing and Lean organizations.

Cellular manufacturing is a process which stands for supporting one-piece flow in production. It helps in facilitating production by having workstations, cells, and equipment well-arranged in order of processes to produce a single or very small batch of products.

This type of production with a cellular layout will allow organizations to make a variety of products very fast. What is very important and special about cellular manufacturing is that it produces all of the products with as little waste as possible.

Generally in manufacturing processes, comparative machines are set close to one another with parts being handled and moved between various divisions in enormous bunches. This can prompt sudden breakdowns, heaped up stock, and superfluous movement, bringing about resources waste.

The biggest problem is that if something turns out badly along the creation line, there is no turning back until it is too late and until it damages the final product. It is very expensive for companies; their money and time go to waste. Also, large scale manufacturing is anything but an adaptable framework and it's hard to roll out any improvements inside the procedures. Cellular manufacturing process enables that products move from cell to cell, with one part of the manufacturing process being completed within each cell.

2. Kaizen and lean manufacturing

Kaizen (改善) is the Sino-Japanese word for "improvement". Kaizen also applies to processes, such as purchasing and logistics, that cross organizational boundaries into the supply chain.

Japanese companies distinguish between innovation (radical) and Kazein (which means continuous). K. means literally: change (kai) to become good (zen).

Kaizen has been one of the most successful continuous improvement approaches of the twentieth century. Mark Hamel, in his Kaizen Event Fieldbook, explains that kaizen is a “prerequisite for lean transformation success”

Kaizen was first drilled in Japanese businesses a while after World War II, impacted to some extent by American business and quality-administration educators, and most prominently as a major aspect of The Toyota Way. It has since spread all through the world and has been applied to situations outside business and efficiency.

Kaizen method elements:

1. Teamwork
2. Personal discipline
3. Improved morale
4. Quality circles
5. Suggestions for improvement

Without Kaizen, there is No Lean Transformation. Kaizen is a part action plan and part philosophy.

The consistent application of Kaizen as an action plan develops Kaizen as a philosophy.

- Point Kaizen
- System Kaizen
- Line Kaizen
- Plane Kaizen
- Cube Kaizen

In 1950 Toyota implemented quality circles leading to the development of Toyota's unique “Toyota Production System”. Toyota is the most successful examples of how to use Kaizen for success, and about Toyota, you will be able to learn more later in this article, as it is one of the most important companies also in World Class Manufacturing.

3. Quality Control in Manufacturing

Quality control (QC) in manufacturing is any exertion that is made to survey the nature of items to distinguish and eliminate defects. In a perfect world, the defects will be found and fixed before the items ever arrive on account of customers. Quality must Be institutionalized for every product. Before you can even consider characterizing a QC (quality control) process, you first need to detail the definite particulars to be institutionalized.

To actualize a viable quality control program, first, make and archive your way to deal with quality control. This incorporates:

- Characterizing the quality norms for every item
- Making and preparing representatives for quality control
- Choosing the quality control technique
- Making a correspondence framework for revealing deformities or potential issues
- Characterizing the quantity of items/cluster that will be tried

World Class Manufacturing in the biscuit industry

WHAT IS Overall Equipment Effectiveness (OEE)?

One great tool that is used in WCM is the calculation of OEE. we can apply OEE in biscuit plant and machines. It reduces the losses and improves the plant/machines. One good tool form which you can analyze the plant/lines/packaging machines is OEE Overall Equipment Effectiveness. Overall Equipment Effectiveness (OEE) measures the operational performance of the production line taking into account Manufacturing Performance losses and Process Driven Losses.

The standard method of calculating OEE considers the actual Good Volume at the end of Line, as it was confirmed at the end of the Production Order, along with the required Loading Time:

Overall Equipment Effectiveness (OEE) =Value Operating Time/Loading Time

World Class Manufacturing is usually represented as a temple with 10 technical and 10 managerial pillars that have to be managed properly.

TEN PILLARS IN WORLD CLASS MANUFACTURING:

SAFETY – HYGIENE & WORKING ENVIRONMENT	*COST DEPLOYMENT*	*FOCUS IMPROVEMENT*	*AUTONOMOUS ACTIVITIES*	*PROFESSIONAL MAINTENANCE*
QUALITY CONTROL	*LOGISTICS AND CUSTOMER SERVICE*	*EARLY PRODUCT MANAGEMENT AND EARLY EQUIPMENT MANAGEMENT*	*PEOPLE DEVELOPMENT*	*ENVIRONMENT*

Every Pillar has a World Class Manufacturing leader, who supervises the activities and motivates the team. There is a Coordinator who is responsible for all activities of World Class Manufacturing.

WORLD-CLASS MANUFACTURING PROCESS

UNIT II

What Is Capacity Planning?

Capacity planning is a type of production planning that involves determining production capacity and workforce needs to make sure your supply chain is equipped to meet demand. Capacity planning lets businesses know how and when to scale, identify bottlenecks, create better design capacity, and mitigate risk, within a planned period of time.

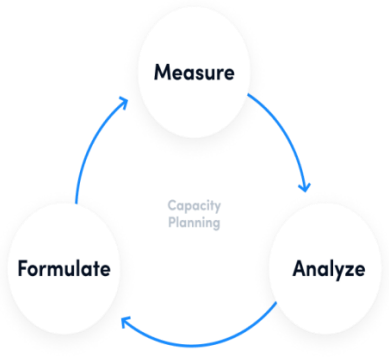
Types of Capacity Planning in Operations Management

There are several types of capacity planning in operations management that can inform your overall strategies:

- **Resource capacity planning** is the lifeblood of a services firm's visibility into what work can be sold and delivered. Resource capacity at a high level is simply a calculation of number of employees multiplied by expected billable hours available in a given week. For most organizations, there has to be at least a few more considerations for optimal resource capacity planning, things like skill sets, utilization targets and work under management and in the sales pipeline create a complete understanding.
- **Project capacity planning**, by contrast, takes a view of a given project within an organization and the time and resources it needs. Project managers estimate the amount of time their assigned team can work in a given timeframe to balance workloads against project delivery milestones. Project capacity planning strategies need to be balanced with strong resource management, ensuring staff aren't overworked (leading to burnout) or underworked (leading to lower profits).
- **Team capacity planning** is useful for groups that typically operate or work together. IT teams with specialized skills, for example, may perform work together on one or more projects. Project managers will use team capacity planning to understand how much work can get done from week to week and how those efforts will affect the project timeline.
- **HR capacity planning** is similar to resource planning but conducted by an HR group who may take into consideration other factors around professional development, ability to hire and onboard new staff and budget for new hires when determining capacity.
- **Tool capacity planning :** Tool capacity planning ensures you have enough tools to complete jobs. This includes any trucks, assembly line components, or machinery you need to manufacture and deliver your product.

How to Start Capacity Planning

There are three basic steps to capacity planning.



1. Measure

First, you'll need to measure your resource capacity. How many deliveries can each of your drivers make in a given period? How many orders can fit onto each of your trucks? How many hours does it take your fleet manager to plan 50 deliveries? It's important to answer these types of questions as accurately as possible because the rest of your plan will be based on these numbers.

2. Analyze

Once you have accurate measurements, you can spend time analyzing this information and determining whether or not you have insufficient capacity or excess capacity, or if you're fully utilizing all available resources. Making graphs will help you understand the numbers and make demand forecasting easier.

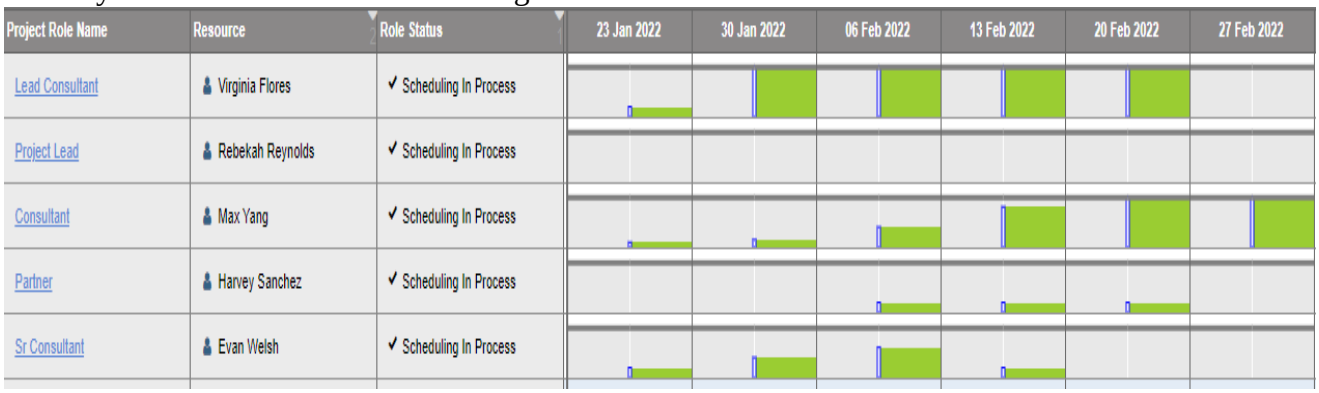
3. Formulate

The final step is taking all of the information you've gathered and formulating a plan. You can make calculations to see how much it will cost to fund new projects or hire a full-time employee vs. bringing on seasonal part-time workers. You could also calculate the ROI for upgrading a piece of machinery or adding assembly lines to your production facilities. The formulation stage helps you see what the likely outcomes are for various options, so you can make the best decision.

Capacity Planning Process

The most effective capacity planning process starts with these steps:

- **Understand current capacity.** What projects, using what people do we currently have under management? What extra time do people have to do more work?
- **Project future demand.** What projects are in our sales pipeline, how certain are they to close and when will they start. What skills will be required for those projects?
- **Identify where additional capacity could come from.** Can we work extra hours, develop new skills? Should we hire more people?
- **Assess your risks.** Will people burn out if we load in more work? What happens if we don't meet demand? Calculate and quantify the risk of lower customer satisfaction if a project can't start on time, or the cost of hiring and retraining employees if people quit. And don't forget the lost opportunity costs associated with not having capacity to sell your services when demand is high.



Project-level capacity template from Projector PSA

Navigating Staffing Shortages With Smarter Capacity Planning

While the upsides to effective capacity planning in operations management include the ability to take on more projects, avoiding employee burnout and better customer service in a tight labor market it can make or break a company.

Considering that trends in staffing continue to point to fewer skilled workers available and increasing demand for their services, it is critical that companies are proactive about understanding their upcoming labor needs. Visibility into capacity translates to more time to plan for spending wisely, whether that means upskilling current staff and/or hiring contractors or full-time employees.

Explain the factors affecting Facility location decision in Operations Management

1. Home
2. Production And Operations Management Tutorial
3. Factors Influencing Plant Location in Operation Management - Production and Operations Management

Factors affecting Facility location decision in Operations Management

Facility location is the process of determining a geographic site for a firm's operations. Managers of both service and manufacturing organizations must weigh many factors when assessing the desirability of a particular site, including proximity to customers and suppliers, labor costs, and transportation costs.

Location conditions are complex and each comprises a different Characteristic of a tangible (i.e. Freight rates, production costs) and non-tangible (i.e. reliability, frequency security, quality) nature.

Location conditions are hard to measure. Tangible cost based factors such as wages and products costs can be quantified precisely into what makes locations better to compare. On the other hand non-tangible features, which refer to such characteristics as reliability, availability and security, can only be measured along an ordinal or even nominal scale. Other non-tangible features like the percentage of employees that are unionized can be measured as well. To sum this up non-tangible features are very important for business location decisions.

It is appropriate to divide the factors, which influence the plant location or facility location on the basis of the nature of the organization as

1. ***General locational factors***, which include controllable and uncontrollable factors for all type of organizations.
2. ***Specific locational factors*** specifically required for manufacturing and service organizations.

Location factors can be further divided into two categories: Dominant factors are those derived from competitive priorities (cost, quality, time, and flexibility) and have a particularly strong impact on sales or costs. Secondary factors also are important, but management may downplay or even ignore some of them if other factors are more important.

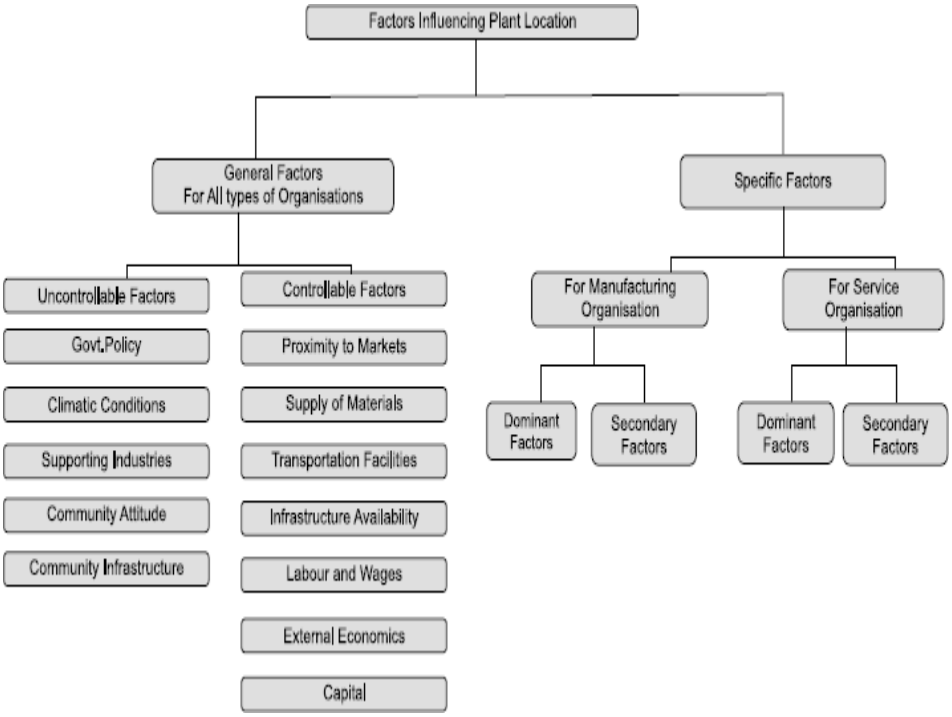
General Locational Factors

Following are the general factors required for location of plant in case of all types of organisations.

CONTROLLABLE FACTORS

1. Proximity to markets.
2. Supply of materials
3. Transportation facilities
4. Infrastructure availability
5. Labour and wages

Factors influencing plant location



6. External economies
7. Capital

UNCONTROLLABLE FACTORS

8. Government policy
9. Climate conditions
10. Supporting industries and services
11. Community and labor attitudes
12. Community Infrastructure

CONTROLLABLE FACTORS

1. ***Proximity to markets:***

   Every company is expected to serve its customers by providing goods and services at the time needed and at reasonable price organizations may choose to locate facilities close to the market or away from the market depending upon the product. When the buyers for the product are concentrated, it is advisable to locate the facilities close to the market. Locating nearer to the market is preferred if

   - The products are delicate and susceptible to spoilage.
   - After sales services are promptly required very often.
   - Transportation cost is high and increase the cost significantly.
   - Shelf life of the product is low.

   Nearness to the market ensures a consistent supply of goods to customers and reduces the cost of transportation.

2. ***Supply of raw material:***

It is essential for the organization to get raw material in right qualities and time in order to have an uninterrupted production. This factor becomes very important if the materials are perishable and cost of transportation is very high. General guidelines suggested by Yaseen regarding effects of raw materials on plant location are:

- When a single raw material is used without loss of weight, locate the plant at the raw material source, at the market or at any point in between.
- When weight loosing raw material is demanded, locate the plant at the raw material source.
- When raw material is universally available, locate close to the market area.
- If the raw materials are processed from variety of locations, the plant may be situated so as to minimize total transportation costs.

Nearness to raw material is important in case of industries such as sugar, cement, jute and cotton textiles.

3. ***Transportation facilities:***

Speedy transport facilities ensure timely supply of raw materials to the company and finished goods to the customers. The transport facility is a prerequisite for the location of the plant. There are five basic modes of physical transportation, air, road, rail, water and pipeline. Goods that are mainly intended for exports demand a location near to the port or large airport. The choice of transport method and hence the location will depend on relative costs, convenience, and suitability. Thus transportation cost to value added is one of the criteria for plant location.

4. ***Infrastructure availability:***

The basic infrastructure facilities like power, water and waste disposal, etc., become the prominent factors in deciding the location. Certain types of industries are power hungry e.g., aluminum and steel and they should be located close to the power station or location where uninterrupted power supply is assured throughout the year. The non-availability of power may become a survival problem for such industries. Process industries like paper, chemical, cement, etc., require continuous. Supply of water in large amount and good quality, and mineral content of water becomes an important factor. A waste disposal facility for process industries is an important factor, which influences the plant location.

5. ***Labor and wages:***

The problem of securing adequate number of labor and with skills specific is a factor to be considered both at territorial as well as at community level during plant location. Importing labor is usually costly and involve administrative problem. The history of labor relations in a prospective community is to be studied. Prospective community is to be studied. Productivity of labor is also an important factor to be considered. Prevailing wage pattern, cost of living and industrial relation and bargaining power of the unions' forms in important considerations.

6. ***External economies of scale:***

External economies of scale can be described as urbanization and locational economies of scale. It refers to advantages of a company by setting up operations in a large city while the second one refers to the "settling down" among other companies of related Industries. In the case of urbanization economies, firms derive from locating in larger cities rather than in smaller ones in a search of having access to a large pool of labor, transport

facilities, and as well to increase their markets for selling their products and have access to a much wider range of business services.

Location economies of scale in the manufacturing sector have evolved over time and have mainly increased competition due to production facilities and lower production costs as a result of lower transportation and logistical costs. This led to manufacturing districts where many companies of related industries are located more or less in the same area. As large corporations have realized that inventories and warehouses have become a major cost factor, they have tried reducing inventory costs by launching "Just in Time" production system (the so called Kanban System). This high efficient production system was one main factor in the Japanese car industry for being so successful. Just in time ensures to get spare parts from suppliers within just a few hours after ordering. To fulfill these criteria corporations have to be located in the same area increasing their market and service for large corporations.

7. ***Capital:***

   By looking at capital as a location condition, it is important to distinguish the physiology of fixed capital in buildings and equipment from financial capital. Fixed capital costs as building and construction costs vary from region to region. But on the other hand buildings can also be rented and existing plants can be expanded. Financial capital is highly mobile and does not very much influence decisions. For example, large Multinational Corporations such as Coca- Cola operate in many different countries and can raise capital where interest rates are lowest and conditions are most suitable.

Capital becomes a main factor when it comes to venture capital. In that case young, fast growing (or not) high tech firms are concerned which usually have not many fixed assets. These firms particularly need access to financial capital and also skilled educated employees.

UNCONTROLLABLE FACTORS

8. ***Government policy:***

   The policies of the state governments and local bodies concerning labor laws, building codes, safety, etc., are the factors that demand attention. In order to have a balanced regional growth of industries, both central and state governments in our country offer the package of incentives to entrepreneurs in particular locations. The incentive package may be in the form of exemption from a safes tax and excise duties for a specific period, soft loan from financial institutions, subsidy in electricity charges and investment subsidy. Some of these incentives may tempt to locate the plant to avail these facilities offered.

9. ***Climatic conditions:***

   The geology of the area needs to be considered together with climatic conditions (humidity, temperature). Climates greatly influence human efficiency and behavior. Some industries require specific climatic conditions e.g., textile mill will require humidity.

10. ***Supporting industries and services:***

    Now a day the manufacturing organization will not make all the components and parts by itself and it subcontracts the work to vendors. So, the source of supply of component parts will be the one of the factors that influences the location. The various services like communications, banking services professional consultancy services and other civil amenities services will play a vital role in selection of a location.

11. ***community and labor attitudes:***

    Community attitude towards their work and towards the prospective industries can make or mar the industry. Community attitudes towards supporting trade union activities are

important criteria. Facility location in specific location is not desirable even though all factors are favoring because of labor attitude towards management, which brings very often the strikes and lockouts.

12. ***Community infrastructure and amenity:***
    All manufacturing activities require access to a community infrastructure, most notably economic overhead capital, such as roads, railways, port facilities, power lines and service facilities and social overhead capital like schools, universities and hospitals. These factors are also needed to be considered by location decisions as infrastructure is enormously expensive to build and for most manufacturing activities the existing stock of infrastructure provides physical restrictions on location possibilities.

Specific Locational Factors for Manufacturing Organization

DOMINANT FACTORS

Factors dominating location decisions for new manufacturing plants can be broadly classified in six groups. They are listed in the order of their importance as follows.

1. Favorable labor climate
2. Proximity to markets
3. Quality of life
4. Proximity to suppliers and resources
5. Utilities, taxes, and real estate costs

1. ***Favorable labor climate:***
   A favorable labor climate may be the most important factor in location decisions for labour-intensive firms in industries such as textiles, furniture, and consumer electronics. Labor climate includes wage rates, training requirements, attitudes toward work, worker productivity, and union strength. Many executives consider weak unions or al low probability of union organizing efforts as a distinct advantage.
2. ***Proximity to markets:***
   After determining where the demand for goods and services is greatest, management must select a location for the facility that will supply that demand. Locating near markets is particularly important when the final goods are bulky or heavy and outbound transportation rates are high. For example, manufacturers of products such as plastic pipe and heavy metals all emphasize proximity to their markets.
3. ***Quality of life:***
   Good schools, recreational facilities, cultural events, and an attractive lifestyle contribute to quality of life. This factor is relatively unimportant on its own, but it can make the difference in location decisions.
4. ***Proximity to suppliers and resources:***
   In many companies, plants supply parts to other facilities or rely on other facilities for management and staff support. These require frequent coordination and communication, which can become more difficult as distance increases.
5. ***Utilities, taxes, and real estate costs:***
   Other important factors that may emerge include utility costs (telephone, energy, and water), local and state taxes, financing incentives offered by local or state governments, relocation costs, and land costs.

SECONDARY FACTORS

There are some other factors needed to be considered, including room for expansion, construction costs, accessibility to multiple modes of transportation, the cost of shuffling people and materials between plants, competition from other firms for the workforce, community attitudes, and many others. For global operations, firms are emphasizing local employee skills and education and the local infrastructure.

Specific Locational Factors for Service Organization

DOMINANT FACTORS

The factors considered for manufacturers are also applied to service providers, with one important addition the impact of location on sales and customer satisfaction. Customers usually look about how close a service facility is, particularly if the process requires considerable customer contact.

PROXIMITY TO CUSTOMERS

Location is a key factor in determining how conveniently customers can carry on business with a firm. For example, few people would like to go to remotely located dry cleaner or supermarket if another is more convenient. Thus the influence of location on revenues tends to be the dominant factor.

TRANSPORTATION COSTS AND PROXIMITY TO MARKETS

For warehousing and distribution operations, transportation costs and proximity to markets are extremely important. With a warehouse nearby, many firms can hold inventory closer to the customer, thus reducing delivery time and promoting sales.

LOCATION OF COMPETITORS

One complication in estimating the sales potential at different location is the impact of competitors. Management must not only consider the current location of competitors but also try to anticipate their reaction to the firm's new location. Avoiding areas where competitors are already well established often pays. However, in some industries, such as new-car sales showrooms and fast- food chains, locating near competitors is actually advantageous. The strategy is to create a critical mass, whereby several competing firms clustered in one location attract more customers than the total number who would shop at the same stores at scattered locations. Recognizing this effect, some firms use a follow –the leader strategy when selecting new sites.

SECONDARY FACTORS

Retailers also must consider the level of retail activity, residential density, traffic flow, and site visibility. Retail activity in the area is important, as shoppers often decide on impulse to go shopping or to eat in a restaurant. Traffic flows and visibility are important because businesses' customers arrive in cars. Visibility involves distance from the street and size of nearby buildings and signs. High residential density ensures nighttime and weekend business when the population in the area fits the firm's competitive priorities and target market segment.

Steps involved in a Procurement Process

Every procurement process involves several elements, including requirements determination, supplier research, value analysis, raising a purchase request, reviewal phase, conversion to purchase order, contract administration, monitoring/evaluation of received order, three-way matching, payment fulfilment, and record keeping. Here are the 7 steps involved in procurement management process:

1. Step 0: Needs Recognition
2. Step 1: Purchase Requisition
3. Step 2: Requisition review

4. Step 3: Solicitation process
5. Step 4: Evaluation and contract
6. Step 5: Order management
7. Step 6: Invoice approvals and disputes
8. Step 7: Record Keeping

Step 1: Purchase Requisition

Purchase requisition are written or electronic documents raised by internal users/customers seeking the procurement team's help to fulfill an existing need. It comprises key information that is required to procure the right goods, services, or works.

Step 2: Requisition review

The procurement process will officially commence only after the purchase requisition is approved and cross-check for budget availability. In the review stage, functional managers or department heads review the requisition package and double-check if there is a genuine need for the requested goods or service and also verify whether necessary funding is available.

Approved purchase requests become POs, while rejected requests are sent back to the requisitioner with the reason for rejection. All these can be handled with a simple purchase order software

Step 3: Solicitation process

Once a requisition is approved and PO is generated, the procurement team will develop an individual procurement plan and sketch out a corresponding solicitation process. The scope of this individual solicitation plan depends ultimately on the complexity of the requirement.

Once the budget is approved, the procurement team forwards several requests for quotation (RFQ) to vendors with the intention to receive and compare bids to shortlist the perfect vendor.

Step 4: Evaluation and contract

Once the solicitation process is officially closed, the procurement team in conjunction with the evaluation committee will review and evaluate supplier quotations to determine which supplier will be the best fit to fulfill the existing need.

Once a vendor is selected, the contract negotiation and signing are completed, and the purchase order is then forwarded to the vendor. A legally binding contract activates right after a vendor accepts a PO and acknowledges it.

Step 5: Order management

The vendor delivers the promised goods/services within the stipulated timeline. After receiving them, the purchaser examines the order and notifies the vendor of any issues with the received items.

Step 6: Invoice approvals and disputes

This is a crucial step in the procurement process and having procurement software like Kissflow Procurement Cloud gives you a competitive edge over others. With Kissflow, you can perform three-way matching between GRN, Supplier Invoice and PO to check if you have received the order correctly and there aren't any discrepancies. Once three-way matching is complete, the invoice is approved and forwarded to payment processing.

Step 7: Record Keeping

After the payment process, buyers make a record of it for bookkeeping and auditing. All appropriate documents right from purchase requests to approved invoices are stored in a centralized location.

Types of Procurement

Procurement can be categorized in several ways. It can be classified as direct or indirect procurement, depending on how the company will use the items being procured. It can also be categorized as goods or services procurement depending on the items that are being procured.

- **Direct procurement** refers to obtaining anything that's required to produce an end-product. For a manufacturing company, this includes raw materials and components. For a retailer, it includes any items purchased from a wholesaler for resale to customers.
- **Indirect procurement** typically involves purchases of items that are essential for day-to-day operations but don't directly contribute to the company's bottom line. This can include anything from office supplies and furniture to advertising campaigns, consulting services and equipment maintenance.
- **Goods procurement** largely refers to the procurement of physical items, but it can also include items like software subscriptions. Effective goods procurement generally relies on good supply chain management practices. It may include both direct and indirect procurement.
- **Services procurement** focuses on procuring people-based services. Depending on the company, this may include hiring individual contractors, contingent labor, law firms or on-site security services. It may include both direct and indirect procurement.

Steps in the Procurement Process

Procurement processes vary greatly depending on each company's structure and needs, but generally include the following nine core steps:

1. Identify which goods and services the company needs. First, a business must identify its requirements for a specific item or a service. This may be a new item that the company hasn't previously purchased, a restock of existing goods or a subscription renewal. This step typically involves delving into the nitty-gritty details of what the business needs, such as the precise technical specifications, materials, part numbers or service characteristics. At this stage, it's a good idea to consult all business departments affected by the purchasing decision to ensure the procured items accurately reflect the needs of each department.

2. Submit purchase request. When an employee or business group needs to procure a significant quantity of new supplies or services, they make a formal purchase request (also known as a purchase requisition). A purchase request notifies the company that a need exists, usually via department managers, purchasing staff or the financial team, as well as specifications such as price, time frame needed, quantity and other important things for the purchasing team to keep in mind. The department overseeing the purchase can then approve or deny the purchase request. If approved, the procurement team can proceed with selecting a vendor and making the purchase.

3. Assess and select vendors. With a clear list of requirements and an approved purchase request, now is the time to find the best vendor and submit a request for quote (RFQ) – this is what the purchasing team sends to potential suppliers in order to receive a quote – it is important to be as detailed as possible so you can compare apples to apples. Vendor assessment should focus not only on cost but also on reputation, speed, quality and reliability. Many companies consider ethics and social responsibility as well, since procurement is often intertwined with corporate identity. A retailer that prides itself on sustainability would stand to benefit from partnering with environmentally responsible suppliers, for instance.

4. Negotiate price and terms. A common best practice is to get at least three quotes from suppliers before making a decision. Examine each quote carefully and negotiate where possible.

If you need to walk away from a deal, be sure that you have concrete alternative options. Once you've agreed on final terms, be sure to get them in writing.

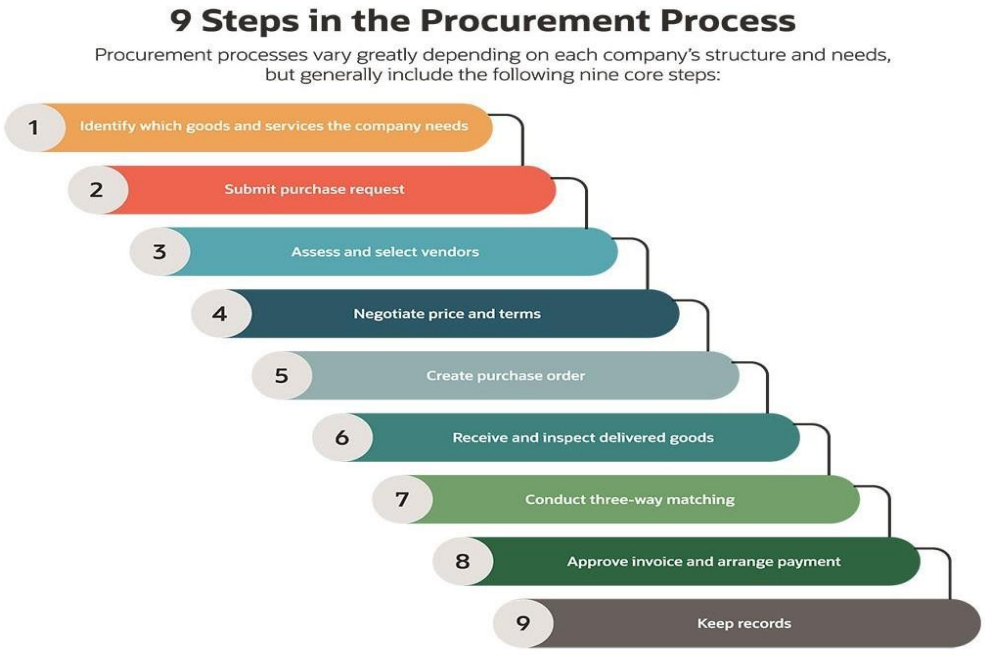
5. Create a purchase order. Fill out a purchase order (PO) and send it to the supplier. The PO should be sufficiently detailed to identify the exact services or goods needed and to enable the supplier to fill the order.

6. Receive and inspect the delivered goods. Carefully examine deliveries for any errors or damage. Make sure everything is delivered as specified in the PO and that the quality meets or exceeds expectations.

7. Conduct three-way matching. Accounts payable should conduct three-way matching by comparing the purchase order, order receipt or packing list and invoice. The goal is to ensure the goods or services received match the purchase order and to prevent payment for unauthorized or inaccurate invoices. Highlight any discrepancies between the three documents and resolve issues before arranging payment.

8. Approve the invoice and arrange payment. If the three-way match is accurate, approve and pay the invoice. Businesses should strive to have a consistent invoice payment process through accounts payable that checks that payments match the invoice amount and due date. A standardized process can help make sure invoices are always paid on time, which can prevent late fees and build good relationships with suppliers.

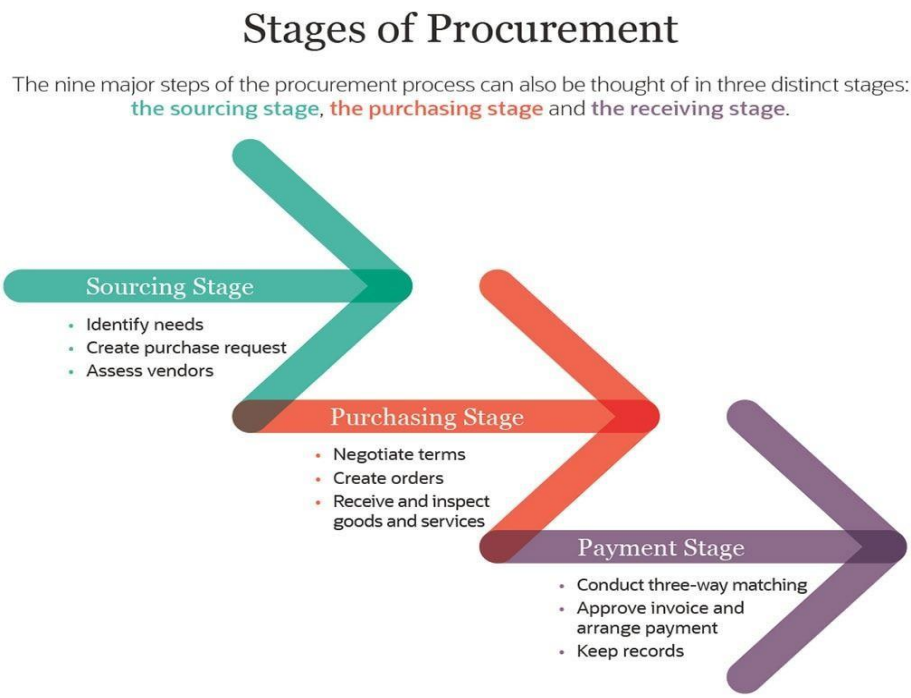
9. Recordkeeping. It's important to maintain records for the entire procurement process, from purchase requests to price negotiations, invoices, receipts and everything in between. These records may be useful for multiple reasons. They help the company reorder goods at the right price in the future, as well as assist with auditing processes and calculating taxes. Clear, accurate records can also help resolve any potential disputes.



Stages of Procurement

The nine major steps of the procurement process can also be thought of in three distinct stages: the sourcing stage, the purchasing stage and the receiving stage.

- **Sourcing stage:** This covers the initial steps in which the business identifies its needs, creates a purchase request and assesses vendors. Even after the initial sourcing steps are complete, it's a good practice to build a strong relationships with suppliers. They can establish grounds for suppliers to learn from partners, improve products and processes and develop trust.
- **Purchasing stage:** This stage includes negotiating terms, creating orders and receiving and inspecting goods and services.
- **Payment stage:** Accounts payable conducts three-way matching to ensure order and invoice accuracy. The invoice can then be approved and the payment is arranged. Records of all invoices, orders and payments should be kept and carefully maintained.



Procurement Life Cycle

Organizations commonly think of steps in the procurement process as a life cycle. This perspective provides a reminder that all the tasks and stages in the procurement process overlap and rely on each other and that the process is continuous. A carefully thought-out procurement life cycle also recognizes the integration between the process and the business as a whole, including the need to align with existing company rules and procedures covering areas such as budgeting. The process is not always linear, and sometimes adjustments need to be made to account for a dynamic digital supply chain with shifting suppliers, availabilities and costs.

Three Components of Procurement

Three key components work together to make the procurement process happen: people, process and paperwork.

- **People:** People generally are responsible for initiating or authorizing every step of the procurement process. In addition to procurement specialists, the people involved include other stakeholders, such as accounts payable and the business groups that request the

goods and services. The number of people involved often depends on the value of the goods and services; more stakeholders may be involved in specifying and approving high-value purchases.

- **Process:** An effective procurement process can help a company succeed by keeping costs down and ensuring supplies arrive when the business needs them. A well-designed and methodical process helps to promote accuracy and timeliness because every person involved knows exactly what they need to accomplish and how long they have to complete the tasks. In contrast, a disorganized procurement process results in inefficiencies and potentially costly errors. Overpayments, for example, can impact the bottom line, while late payments negatively affect relationships with suppliers.
- **Paperwork:** It's important to maintain records for every stage of the procurement process and ensure they are easily accessible. These records act as a store of organizational knowledge about payment terms and supplier performance, helping the business maintain an efficient procurement process — even if the procurement staff changes over time. In the case of an audit or a dispute, a business must be easily able to follow the paper or electronic trail through each stage of the procurement process.

UNIT-II

FORECASTING, CAPACITY AND AGGREGATE PLANNING

DEMAND FORECASTING:

- Forecast: A statement about the future.
- Forecasting: Estimating the future demand for products/services and the resources necessary to produce these outputs.
- Forecasting defined: Forecasting is the first step in planning. It is defined as estimating the future demand for products and services and the resources necessary to produce these outputs.
- Estimates of the future demand for products or services are the starting point for the entire sales forecasts

DEMAND FORECAST:

- According to Fayol, "Forecasting is the essence of management. Its techniques are used in every type of organization may it be government or private, production or service and social or religious".
- According to McFarland, "Forecasts are predictions or estimates of the changes if any in characteristic economic phenomena, which affect one's business plan".
- Forecasting is the study of internal and external forces that shape demand and supply.

CHARACTERISTICS:

1. It is the basis of planning, production program.
2. It is an estimate of sales in the future.
3. The basis of forecasting is past trends and present economic conditions.
4. Forecasting is done for a particular period.
5. It can be in the shape of money or in the shape of a unit of a commodity.
6. It depends on market planning, economic, or other factors.
7. It tries to find-out lines of profitable investment.
8. It helps the firm in planning for trained manpower.
9. It tries to arrange appropriate promotional efforts such as advertisement, sales campaign etc.

NEED OF DEMAND FORECASTING:

Demand forecasting is needed for:

New facility Planning:

Designing and building a new facility (factory) or designing and implementing a new production process, and long-range forecasts of demand for existing. Designing and building a new facility (factory) or designing and implementing a new production process may take as long as five years or even more.

- These strategic activities are based on long-range forecasts of demand for existing and new products to allow the needed lead time for production and operations managers for plant location, plant layout, installation of machinery and equipments to produce the products and services to meet the demand.

Production Planning:

The rate of producing the products must be matched with the demand which may be fluctuating over the time period in the future.

- Work force scheduling: The forecasts of monthly demand may further be broken down to weekly demands and the workforce may have to be adjusted to meet these weekly demands.

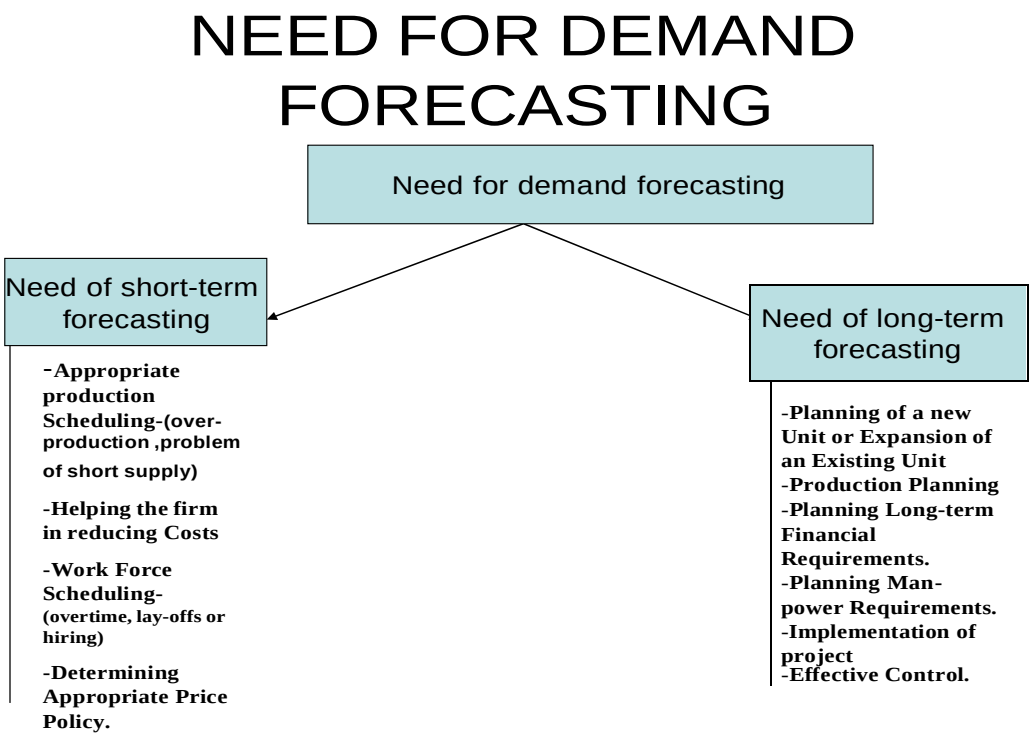
Financial Planning:

Sales Forecasting are the driving force in budgeting. Sales forecasts provide the timing of cash inflows (sales revenues) and also provide a basis for budgeting the requirements of cash outflow for purchasing materials, payments to employees and to meet other expenses of power and utilities etc.

- Hence, sales forecasts help finance manager to prepare budgets taking into consideration the cash inflows and cash outflows.

Workforce Scheduling:

- The forecasts of monthly demand may further be broken down to weekly demands and the workforce may have to be adjusted to meet these weekly demands.
- This may be done through reassignment of jobs to workforce, allowing overtime work, layoffs or hiring in order to match the weekly production rates with the weekly demands.
- Hence, short-range forecasts are needed to enable managers to have the necessary lead time to fine tune the workforce changes to meet the weekly production demands.



TYPES OF FORECAST:

1. Technological Forecasts: Concerned with rates of technological progress. It will provide changes will provide many companies with new products and materials to offer for sale.
2. Economic forecasts: Statements of expected future business conditions published by governmental agencies.
3. Demand Forecasts: Projections of demand for a company's products or services throughout some future period, it provides the basis for the company's planning and control decisions.

These forecast drive a company's production capacity and scheduling systems and serve as inputs to financial, marketing and human resource (manpower) planning.

FORECASTING TIME HORIZONS:

- (i) Short-range forecast: This forecast has a time span of upto one year, but is generally less than three months.
- It can be even for monthly or weekly forecasts.
- It is used for planning purchasing, job-scheduling, workforce levels, job assignments and production levels.
- (ii) Medium-range forecast (or intermediate range):
- A Medium range or intermediate range forecast generally spans from 3 months to 3 years.
- It is used in sales planning, production planning and budgeting (quarterly/yearly), cash budgeting and analyzing various operating plans.

(iii) Long-range forecast:

- Generally 3 years or more in time span, long range forecasts are used in new product planning and development, capital expenditure planning and planning for facility location or expansion and research and development.

TYPES AND CHARACTERISTICS OF FORECASTS BASED ON TIME HORIZON:

Forecast Horizon	Applications	Characteristics	Forecast Methods

Long-range(3 to 5 yrs. or more)	Business planning, Product planning, Capital Planning, Facility planning, Location planning	Broad, general, often only qualitative	Technological, Economic, Demographic, Marketing studies, Judgment.
Medium or intermediate(3 to 3 years)	Aggregate Planning, Capital and cash Budgets, Production Planning and budgeting, inventory planning and budgeting.	Numerical, not necessarily at the item level. Estimate of reliability needed.	Collective opinion, Time series / Regression analysis, judgment.
Short-range(1week to 3 months)	Short run adjustment of production and personal levels, purchasing, job scheduling, capacity changes by over time, lay offs etc.	May be at the item level for planning of activity level, should be at the item level for purchasing and inventory control.	Exponential, Smoothing.

ELEMENTS / REQUIREMENTS OF A GOOD FORECAST:

The forecast should be timely. This means that the forecasting horizon must have the time necessary to implement possible changes in production capacity, financial needs etc.

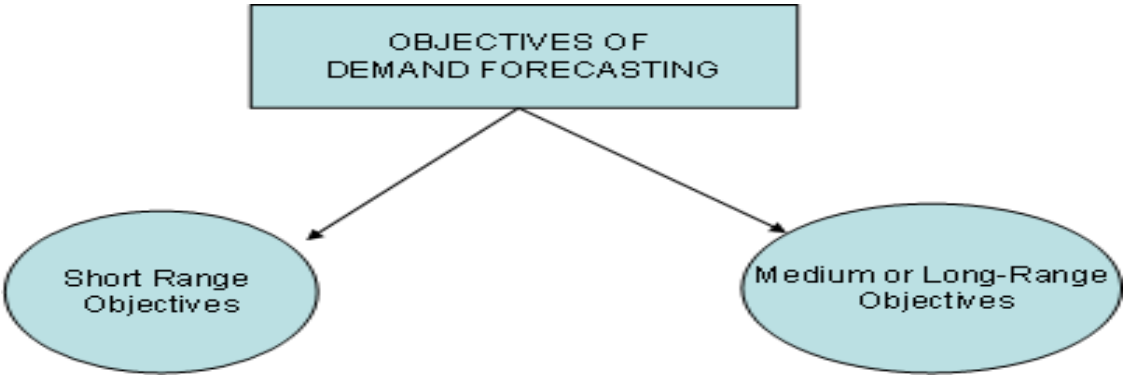
(ii) The forecast should be accurate and the degree of accuracy should be known.

(iii) The forecast should be reliable.

(iv) The forecast should be expressed in meaningful units such as rupees, units of products, machines and skills needed.

(v) Techniques should be simple.

(vi) The forecast should be in the written form to permit an objective basis for evaluating the forecast once the actual results are known.



SHORT RANGE OBJECTIVES:

- Objectives are:

1. Formulation of production strategy and policy: To Bridge the gap betn demand and supply of a product offered by the firm and to ensure.- The requirements of materials to be purchased on a regular basis.-Optimum utilization of plant and equipments.- Planning the availability of labor on a regular basis.
2. Formulation of pricing policy: Demand forecasts enable management to formulate a suitable mechanism for fixing the prices for products to be sold.
3. Planning and control of sales: Demand Forecasts facilitate territory design and determination of sales quotas to be assigned to sales people.
4. Financial planning: Demand Forecasts Facilities estimating cash inflows and cash outflows for the products which forecasts are made.

MEDIUM OR LONG-RANGE OBJECTIVES:

Long-range planning for production capacity: The installed capacity of the plant is usually based on long-term demand forecasts.

(ii) Labor requirements (Employment levels): Employment levels are based on reliable medium /long term demand forecasts so as to optimize the cost of production over the long term planning horizon.

(iii) Restructuring the capital structure: Long term forecasts facilitate planning for long term finance requirements at reasonable finanacial coasts and other terms and conditions for obtaining finance from lending institutions as well as planning for internal finanacial resources to meet the long-term financial needs.

STEPS IN DEMAND FORECASTING:

1. Understand the objective of forecasting
2. Integrate demand planning and forecasting throughout the supply chain
3. Understand and identify customer segments.
4. Identify Major factors that influence the demand forecast.
5. Determine the appropriate forecasting technique.
6. Establish performance and Error Measures for forecast.

STEPS IN FORECASTING PROCESS:

(i) Determine the purpose (objectives) of the forecast: details required in the forecast ,the amount of resources (manpower, computer time, rupees etc.)

(ii) Select the items for which forecasts are needed: Determine whether the forecast needed for a single product or for a group of products (Product -line).

(iii) Determine the time horizon for the forecast: Short-term, medium term, long term./ monthly, quarterly, or Yearly.

(iv) Select the forecasting model (method or technique): Quantitative- Moving Averages, exponential Smoothing and regression analysis. Qualitative techniques such as judgmental or market research method.

(v) Gather and analyze the data needed for the forecast:

(vi) Prepare the forecast: Using the Selected method.

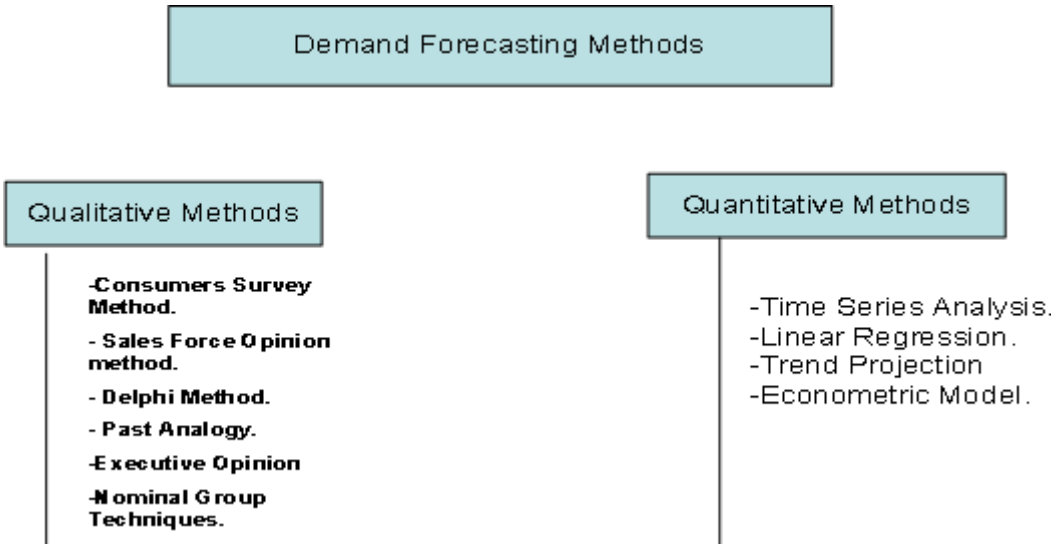
(vii) Monitor the forecast: Monitor the forecast to determine whether it is performed satisfactorily. If not, review the method, assumptions, validity of data and modify the forecast if needed and prepare a revised forecast.

FORECASTING APPROACHES:

The two approaches to forecasting are:

(i) Qualitative: It consists mainly of subjective inputs, often of non-numerical description.

(ii) Quantitative: It involves either projection of historical data or the development of association models which attempt to use causal variables.



QUALITATIVE METHODS:

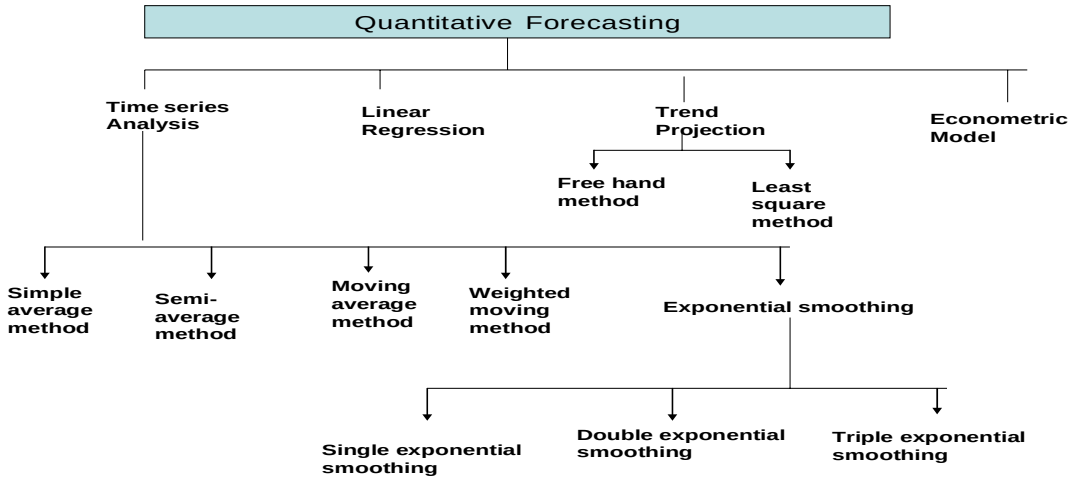
Methods of Qualitative Forecasting:

1. Consumers Survey Method:
   - Complete Enumeration Survey.
   - Sample Survey And test marketing.
   - End-use Method.
2. Sales Force Opinion Method:
3. Delphi Technique:
4. Past Analogy.
5. Executive Opinion-
6. Nominal Group Technique- problem solving& decision making method.

QUANTITATIVE DEMAND FORECASTING METHOD:

- Quantitative/ statistical methods are considered to be superior techniques of demand estimation because:

1. The element of subjectivity in this method is minimum.
2. Method of estimation is scientific.
3. Estimation is based on the theoretical relationship between the dependents and independents variables.
4. Estimates are relatively more reliable, and
5. Estimates involves smaller cost.



TIME SERIES:

- Time series forecasting methods are based on analysis of historical data (time series; a set of observations measured at successive times or over successive periods.)
- They make the assumption that past patterns in data can be used to forecast future data points.
- According to Morris Hamburg, “A time series is a set of observations arranged in chronological order”.
- According to Kenny And keeping, “ A Set of data depending on the time is called time series”.

METHODS OF TIME SERIES ANALYSIS

- TIME SERIES Analysis can be done by two methods:

1. Simple Average Method: In this model, the arithmetic average of the actual sales for a specific number of recent past time periods is taken as the forecast for the next time period.

Simple Average = Sum of demands for all past periods

Number of demand periods

Semi-Average Method

- In this method, the original data is divided into two equal parts and averages are calculated for both the parts.
- These averages are called semi-averages.

Moving- Average Method:

- Moving Average method is a simple device of reducing fluctuations and obtaining trend values with a fair degree of accuracy.
- In this method, the average value of a number of years (months, weeks or days) is taken as the trend value for thee middle point of the period of moving average.
- The process of averaging smoothes the curve and reduces the fluctuations.

Weighted Moving Average Method

- Sometimes trend values are determined by using weighted moving average.
- In this method, the moving totals are multiplied by the weights assigned to them and the weighted moving average is obtained by dividing this product by the sum of the weights.

Exponential Smoothing

- Exponential smoothing models are well known and often used in operations management. The reasons for their popularity are two:

(i) They are readily available in standard computer software packages.

(ii) They require relatively little data storage and computation.

TYPES OF EXPONENTIAL SMOOTHING:

i) Single Exponential Smoothing: The equation for creating a new or updated forecast uses two pieces of information:

a) Actual demand for the most recent period, and

b) The most recent demand forecast.

As each time period expires, a new forecast is made:

Forecast of next period's demand = α (Actual demand for most recent period) +
(1- α)(Demand forecast for most recent period).

Exponential Smoothing with trends (Double-Exponential Smoothing):

- An Exponential Smoothing over an already smoothed time series is called double-exponential smoothing.
- Double-exponential smoothing allows forecasting data with trends.
- This method is better at handling trends that are not stationary.

iii) Triple-Exponential Smoothing:

- In the case of non-linear trends, it might be necessary to extend it even to a triple-exponential smoothing.
- Triple-exponential smoothing is better at handling parabola trends and is normally used for such data.

OVERVIEW OF QUALITATIVE METHODS:

1. Jury of Executive Opinion.
2. Sales force Composite Method
3. Market Research Method (or Consumer Survey Method)
4. Other Judge mental Methods: Delphi Method

JURY OF EXECUTIVE OPINION:

It is a forecasting technique in which the opinions of a small group of high-level executives (managers) are taken, based on which a group demand is obtained as the forecast.

Advantages:

- Can be used for technological forecasting.
- Can be used to modify an existing forecast to account for unusual circumstances.
- Disadvantages:
- Executive opinion can be costly because it takes valuable executive time.
- It sometimes gets out of control or gets delayed.

SALES FORCE COMPOSITE METHOD:

- This is also called as "Pooled sales force estimate" method.
- It is based on estimate of expected sales by sales persons.
- Advantages:
- The sales force is the group closest to the customers
- Sales territories often are divided into districts or regions and forecast will be useful in inventory management, distribution and sales force staffing.
- Disadvantages:
- Individual biases of sales people may affect the sales forecast (some are optimistic, some are pessimistic.)

MARKET RESEARCH METHOD OR CONSUMER SURVEY METHOD:

- This is a systematic approach to determine consumer interest in a product or service by conducting a consumer survey and sample consumer opinions.
- This method may be used to forecast demand for the short, medium and long-term.

OTHER JUDGE MENTAL METHODS: DELPHI METHOD:

- In this method, opinions are solicited from a number of other managers and staff personnel.
- The decision makers consist of a group of 5 to 10 experts who will be making the actual forecast.
- The staff personnel assist decision makers by preparing, distributing, collecting and summarizing a series of questionnaires and survey results.

It is a judgmental method which uses a group process that allows experts to make forecasts.

Quantitative Forecasting	Qualitative Forecasting
1) Quantitative forecasting methods use mathematical models to represent relationships among relevant variables based on historical data and / or known relationships.	In contrast, qualitative forecasting methods rely on one or more individuals to generate forecast without using mathematical models alone; e.g., a sales manager may predict future sales for the division based on informal discussions with some customers.

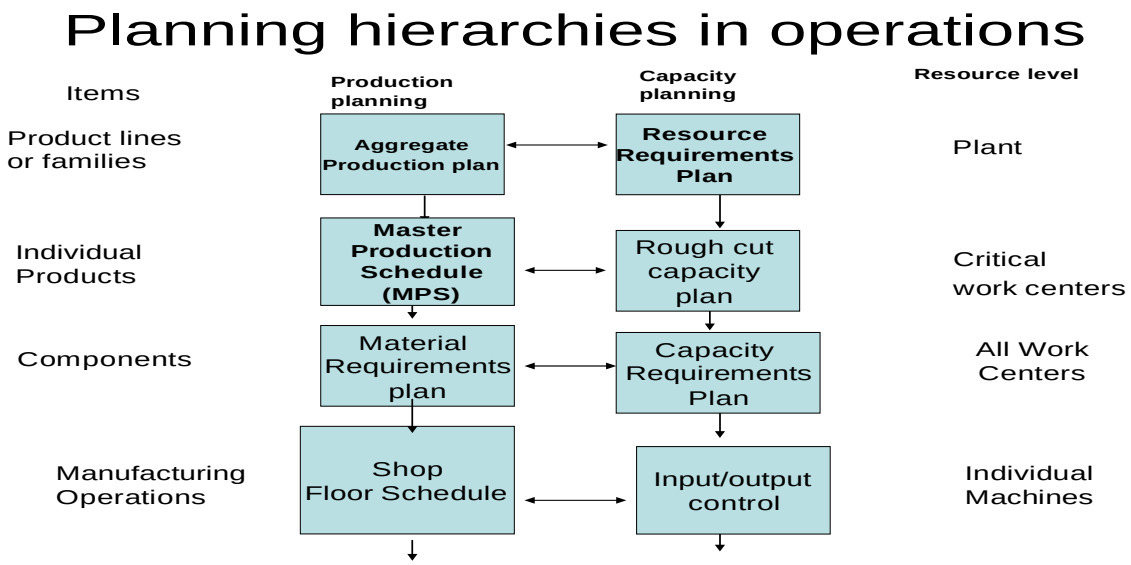
2) Quantitative forecasting models are used in conjunction with historical data to forecast demands (or some other quantity).	Qualitative forecasting incorporates the forecaster's experiences, intuition, values and personal biases into the forecast.
3) These methods are sometimes referred to as objective forecasting methods because the underlying assumptions of the forecasting model and the data used can be stated precisely, independent of the user. Thus, if two individuals use the same model and same data, they should get the same forecasts.	These are considered subjective forecasting methods because there is no way to determine exactly what information is being used by the forecaster and how. Such forecasts are specific to the forecaster and cannot be duplicated by others. For ex: If two individuals attempt to predict the market penetration of a new product, their forecasts will be different because the are Drawing on different experiences and are likely to weight the importance of those experiences differently.

CAPACITY PLANNING:

Meaning: Capacity is the rate of productive capacity of a facility. Capacity is expressed as volume of output per time period.

Operations manager are concerned with the capacity for reasons:

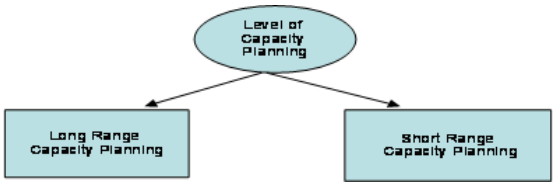
1. They want sufficient capacity to meet customer demand in time.
2. Capacity affects cost efficiency of operations, the ease or difficulty of scheduling output and the costs of maintaining the facility.
3. Capacity requires an investment of capital.



Definition of Capacity planning

- According to APICS, "Capacity planning or capacity requirements' planning is the function of establishing, measuring and adjusting limits or levels of capacity."
- The term 'capacity Requirements Planning' in this context is the process of determining how much labor and machine resource is required to accomplish the tasks of production".
- It is also defined as "Capacity Planning is the study of the level of capacity the organization provides at each stage of the production or service delivery system to meet its objective."
- Capacity Planning is the process used to determine how much capacity is needed in order to manufacture greater product or begin production of a new product.

Long Range Capacity Planning



LONG RANGE CAPACITY PLANNING:

- Over the long term,capacity planning relates primarily to strategic issues involving the firm's major production facilities.

- Technology and transferability of the process to other products is also intertwined with the long term capacity planning.
- Long term capacity planning may evolve when short term changes in capacity are insufficient.
- For ex: If the firm's Addition of a third shifts to its current two-shift plan still does not produce enough output, and subcontracting arrangements cannot be made, One feasible alternative is to add capital equipment and modify the layout of the plant (long term actions).
- It may even be desirable to add additional plant space or to construct a new facility (long-term alternatives).

SHORT RANGE CAPACITY PLANNING:

- In short term, capacity planning concerns issues of scheduling, labor shifts and balancing resource capabilities.
- The goal of short-term capacity planning is to handle unexpected shifts in demand in an efficient economic manner.
- The time frame for short-term capacity planning is frequently only a few days but may run as long as six months.

OBJECTIVES OF CAPACITY PLANNING:

The decisions taken by operations managers in devising their capacity plans will affect several different aspects of performance:

- Costs: capacity levels in excess of demand could mean under-utilization of capacity and therefore high unit cost.
- Revenues: It is also affected by the balance between capacity and demand.
- Working Capital: It will be affected if an operation decides to build up finished goods inventory prior to demand.
- Quality: By hiring temporary staff.-disruption to the routine working of the operation.
- Speed: By the deliberate provision of surplus capacity to avoid queuing.
- Dependability:- how close demand levels are to capacity.
- Flexibility:-volume flexibility will be enhanced by surplus capacity.

TYPES OF CAPACITY PLANNING: There are two types of capacity planning:

1. Rough-cut capacity Planning (RCCP).
2. Capacity Requirements Planning (CRP).

Rough-cut capacity Planning (RCCP):

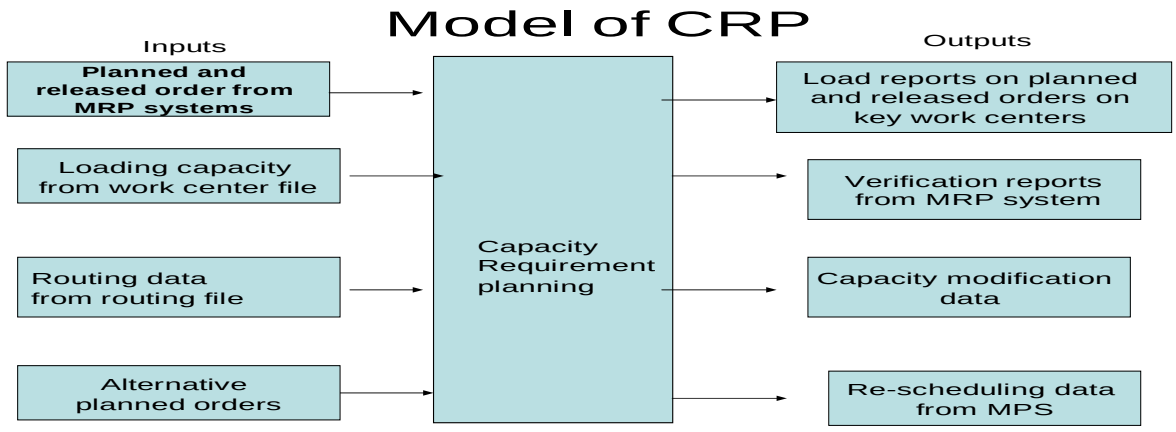
- Rough-cut capacity Planning (RCCP) is very important plan in capacity planning of firm.
- It takes capacity planning to the next level of detail.
- The Master Production Schedule (MPS) is the primary source of information for RCCP.
- RCCP is a medium-range planning aid and is used to verify whether enough available capacity exists at critical resources to accomplish a projected master production schedule.
- The purpose of RCCP is to check the feasibility of the MPS, provide warnings of any bottlenecks, ensure utilization of work centers, and advise vendors of capacity requirements.
- RCCP provides aggregate information to top management far enough in advance to permit management to make changes in capacity (i.e. hire more people, buy more equipment) to accomplish a given MPS.

Capacity Requirements Planning (CRP):

- Capacity Requirements Planning (CRP) occurs at the level of the material requirements plan.
- It is the process of determining in detail the amount of labor and machine resources needed to achieve the required production.
- Planned orders from the MRP and open shop orders (scheduled receipts) are converted into demand for the time in each work centers accordingly.
- CRP is the last level of capacity analysis. it is planning and control of the resources needed to produce the requirements generated by the MRP system.

Basis of difference	RCCP	CRP
1)What	1) Projected gross capacity 2) Requirements for key resources.	Projected net capacity Requirements for each work center.
2) How	Explode production plan or MPS through resource profiles.	Explode MPS and MRP I planned orders through detailed routings combine with current WIP status from shop floor control.
3) When	As required for simulation	Weekly, monthly
4) Why	pre-MRP I evaluation of MPS.	1)Post-MRP I detailed analysis

	Intermediate to long range planning.	
5) Precision	Aggregate or gross key resources only.	Detailed- considers inventory, lot sizing WIP completions, Work center lead times
6) Complexity	Much less than CRP	Usually exceeds MRP I.
7) Planning Horizon	Production plan limits	MRP I Horizon
8) Implementation	Short	Requires work centers, routings, MPS< MRP I and WIP status of SFC.



Capacity Alternatives:

1. **Short-term Responses:** For short-term periods of up to one year, fundamental capacity is fixed.

- Major facilities are seldom opened or closed on a regular monthly or yearly basis.
- Short term capacity can be modified by operating these facilities more or less intensively than normal.

➢ The cost of setting up, changing over, and maintaining facilities, procuring raw materials and manpower, managing inventory, and scheduling can all be modified be such capacity changes.

Temporary capacity changes:

TYPE	ACTION
inventories	Stock pile finished goods during slack periods to meet later demand.
Backlogs	During peak demand periods, ask willing customers to wait time before receiving their product. File their order and fulfill it after the peak demand period.
Employment levels	Hire additional employees or lay off employees as demand for output increases and decreases.
Work force utilization	Have employees work overtime during peaks and be idle or work fewer hours during slack demand periods.
Employee training	Instead of having each employee specialize in one task, train each in several tasks, then as skill requirements changes, rotate employees among different tasks.
Process design	Change the current job content workstation to increase productivity. Use work methods analysis to redesign jobs.
Subcontracting	During peak periods, hire other firms temporarily to make the product or some of its subcomponents.
Maintenance	Temporarily discontinue routine preventive maintenance on facilities and equipment so that during peak periods the facility can be operated when it would otherwise be idle.

Long-term Response:

- Long-term consideration relates to overall level of capacity, such as facility size. It requires forecasting demand over a time horizon and then converting those forecast into capacity requirement. Following strategies are:

1. Long-term Capacity Expansion.
2. Long-term Capacity Reduction.

Evaluating Capacity Alternatives:

- Models available to assist in capacity planning as follows:

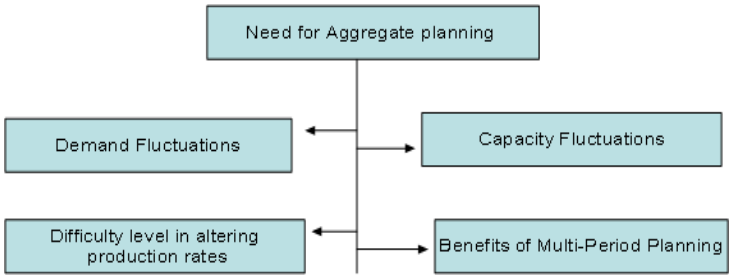
1. Present Value Analysis: (time value of capital investment.)
2. Break-even Analysis: (min. break even volume for project cost and revenue.)

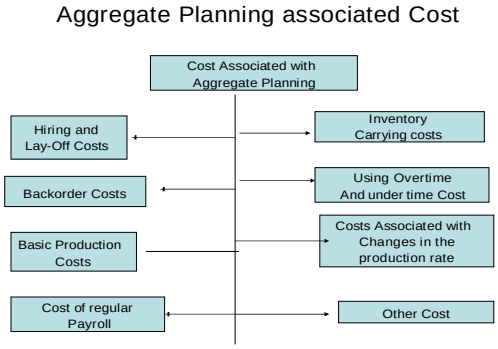
3. Linear Programming: (the model focuses on short run question of ways to use existing capacity in order to optimize the utilization of resources.)
4. Decision Tree Analysis: (for the analysis of capacity expansion decisions, decision tree analysis is often used.)

AGGREGATE PLANNING:

- Aggregate planning is the process of developing, analyzing and maintaining a preliminary, approximate schedule of the overall operations of an organization.
- The Aggregate plan contains sales forecasts, production levels, inventory levels, and customer backlogs.
- In simple terms, aggregate planning is an attempt to balance capacity and demand in such a way that costs are minimized.
- The term "Aggregate" is used because planning at this level includes all resources "in the aggregate" e.g. as a product line or family.
- Aggregate resources could be total number of workers, hours of machine time, or tonnes of raw materials.

APPROACHES OF AGGREGATE PLANNING:





- An aggregate plan takes into consideration the overall level of output and the capacity i.e. required to produce it
- These are two basic approaches to estimating the capacity that will be required to produce an aggregation or grouping of a company's products, which are as follows.
- Top-down Approach

- Bottom-up Approach

  Top-down Approach:

- It involves development of the entire plan by working only at the highest level of consolidation of products.
- It consolidates the products into an average product and then develops one overall plan.
- This plan is disaggregated to allocate capacity to product families and individual products.
- This approach rests on the assumption that if the proper amount of total capacity is available, the right amount of capacity for all of the parts will be available.
- This top-down approach is performed in terms of a pseudo-product which is a fictitious product that represents the average characteristics of the entire product line to be planned.

  Bottom-up Approach:

- It is also known as sub-plan consolidation approach.
- It involves development of plans for major products and product families at some lower level, within the product line.
- These sub-plans are then consolidated to arrive at the aggregate plan, which gives the overall output and the capacity required to produce it.
- This approach starts with plans for major products or product families and aggregate (sums) the impact that these plans have on the capacity of the company.
- If the capacity requirements for individual plans appear to sum-up to a satisfactory overall use of the company's resources the plans are accepted to be implemented strategically. If not, some of the individual plans are revised to improve the overall impact of the aggregate plan.
- This is also called "resource requirement planning" and "rough-cut capacity planning.

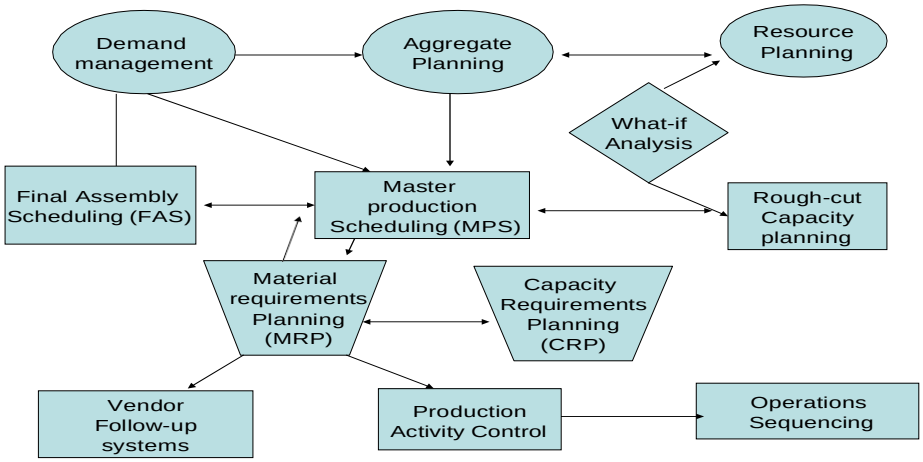
AGGREGATE PLANNING PROCESS:

- The process for basic considerations as follows:

1. Concept of Aggregation
2. Goals for Aggregate Planning
3. Aggregate Demand forecasts
4. Interrelationships among decisions

RELATIONSHIP TO MASTER PRODUCTION SCHEDULE

- Aggregate Planning (AP) and Master Production Scheduling (MPS) are two important functions in Manufacturing Resource Planning Proper interfaces between the two functions will greatly enhance the effectiveness of the whole Manufacturing Planning and Control (MPC) system.
- Aggregate Planning (AP) and Master Production Scheduling (MPS) is the front end of most production and operations planning and control systems.
- In aggregate production planning, management is concerned with determining the aggregate levels of production, inventory, and workforce to respond to fluctuating demands in the future.
- The aggregate plan provides an overall guideline for master production scheduling, which specifies the timing and volume of the production of individual products.
- The master scheduler takes the aggregate decisions as targets and tries to achieve them as much as possible.
- Ideally, the sum of production (and inventory) quantities in the master schedule over a time period should equal the aggregate production (and inventory) quantities for that time period.
- However, deviations may occur due to factors such as capacity limitations at critical work-centers.
- The feedback from actual master scheduling performance provides information for improving future aggregate plans.
- To be feasible and acceptable, a master production schedule should meet the resource constraints at critical work centers.
- This feasibility check is called ""resource requirement planning" (RRP) or "rough-cut capacity planning (RCP).



Overview of MRP, MRP II and ERP

- MATERIAL REQUIREMENT PLANNING (MRP).
- MANUFACTURING RESOURCES PLANNING (MRPII).
- ENTERPRISE RESOURCE PLANNING (ERP).

MATERIAL REQUIREMENT PLANNING (MRP)

- According to American Production and Inventory Control Society (APICS), " MRP constitutes a set of techniques that use bill of material, inventory data, and the master production schedule to calculate the requirements for materials."

OBJECTIVES OF MRP

1. Inventory Reduction
2. Reduction in production and delivery lead times
3. Realistic Commitments
4. Increased Efficiency

NEED FOR MRP

1. Forces the planner to determine the total material
2. Helps in development of procedure and systems
3. Focuses on control parameters
4. Classification for inventory item
5. Fixing of norms for shelf life
6. Arranging items of correct specifications.

INPUT /OUTPUT OF MRP SYSTEM

- An MRP system translates the demand for end products into raw materials and three components requirements to all available variants of MRP systems are:

1. Inputs
2. MRP processing (material flow in MRP).
3. Outputs.

Inputs to MRP

- MRP is a processor which processes inputs (relating data) to give a time phased detailed schedule for raw materials and components.
- These inputs are:

1. Master production Schedule (MPS).
2. Bill of materials (BOM)
3. Inventory status file (ISF)- information such as- Inventory status, replenishment lead times, and manufacturing lead time.

MANUFACTURING RESOURCES PLANNING (MRPII):

- According to APICS,MRP II is defined as a "a method for effective planning of all the resources of manufacturing company.
- Ideally it addresses operational planning in units, financial planning in dollars and has a simulation capability to answer ' what –if' questions .
- It is made up of variety of functions each linked together; business planning, production planning, master production scheduling, material requirements planning, capacity requirements planning and the execution system for capacity and priority.

BENEFITS OF MRPII:

1. Effective Inventory Management and control
2. Improved Capacity Planning
3. Better Priority
4. Enhanced Customer Service
5. Improved Management
6. Enhanced employee Morals
7. Effective Long-range Planning Tool

UNIT III

INTRODUCTION:

Product is anything that can be offered to a market that might satisfy a want or need.

- Two concepts are:
- Narrow concept- A product is a bundle of physical or chemical properties which has some utility.
- Wide concepts- All the brands, all the colors all the packaging or all the designs of a product is taken to be different products.
- According to W. Alderson, "A product is a bundle of utilities consisting of various features and accompanying services".
- According to Philip Kotler, "A Product is a bundle of physical services and symbolic particulars expected to yield satisfaction or benefits to the buyer".

MEANING, DEFINITION- PRODUCT DESIGN:

- Design is the conversion of knowledge and requirement into a form, convenient and suitable for use for manufacture.
- It is observed that inputs of the organizations resource resulting properly designed product and service known as outputs satisfying the customer's desire.
- According to C.S.Deverell, " Product design in its broadest sense includes the whole development of the product through all the preliminary stages until actual manufacturing begins".
- In other words, design means determination of shape, standard and pattern of the product.

OBJECTIVES OF PRODUCT DESIGN:

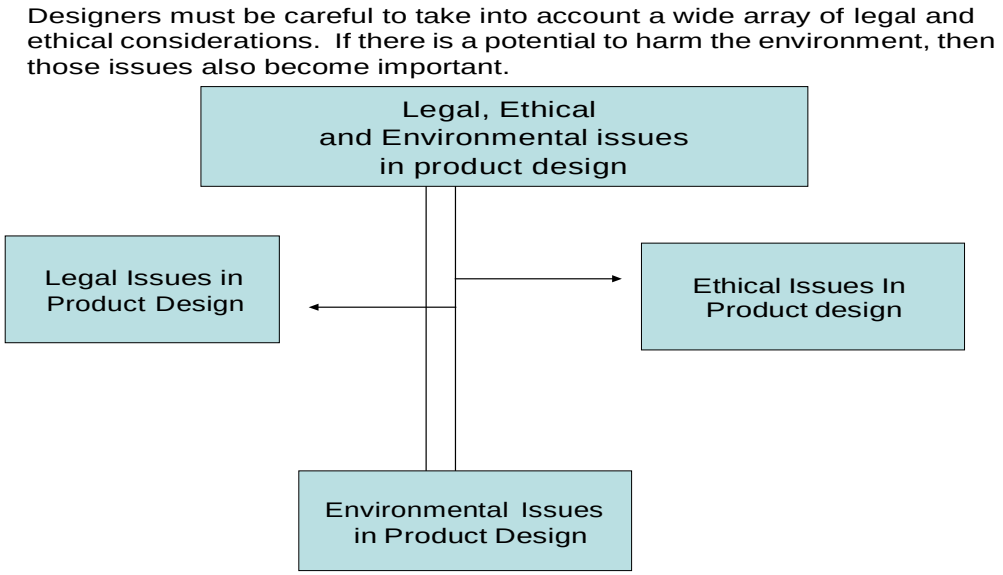
- The objects of designing the product may be summarized as follows:

1. The first object of designing is to create attention in product for increasing the sale potentials.
2. To enlarge the importance of product from customer's point of view.
3. To make the product more effective and create more utility in the product for the consumer.
4. To produce better quality at the lowest possible price.

Approaches/ Elements

1. Research and Development

2. Reverse Engineering
3. Manufacturability
4. Standardization
5. Modular Design
6. Robust Design
7. Concurrent Engineering
8. Computer-aided Design
9. Life-cycle Of a Product



LEGAL ISSUES IN PRODUCT DESIGN:

- The legal issues play a crucial role in the design process. They are as follows:

  i) Product Liability:

  ii) Intellectual Property: It refers to property of the mind or intellect. IP is legally protected and a designer must be aware of this.

  Protecting IP is essential if research and development is to remain the property of the designer.

  It is a means to ensure that the financial gain from the design goes to the creator of the intellectual property.

ETHICAL ISSUES IN PRODUCT DESIGN:

- That influence designers They include:

i) Assessing the Impact of the Design on Consumer

ii) Protection of intellectual property.

iii) Privacy.

iv) Exposure to the Undesirable.

v) Advertising Of Designs.

vi) Right to Alter Natural Orders.

vii) Whether designs should be tested on Animals and Human.

viii) Environmental Impact

ix) Sustainable Technology.

x) Minority Groups.

ENVIRONMENTAL ISSUES IN PRODUCT DESIGN

i) Greenhouse Effect or Global Warning

ii) Ozone Layer

iii) Tropical Deforestation

iv) Waste

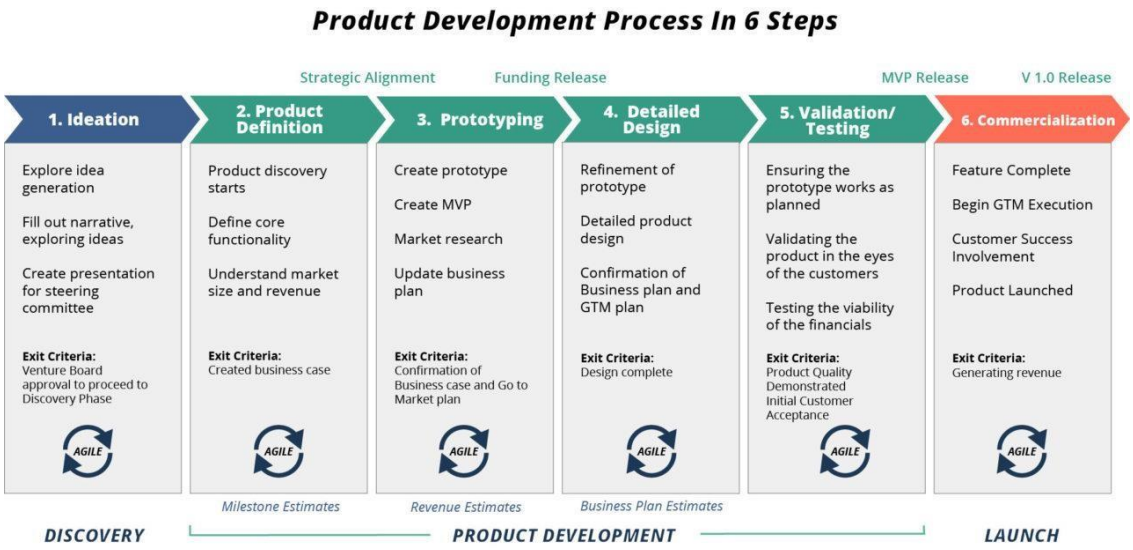
v) Water Pollution

vi) Resource Consumption

What is a Product Development Process?

A Product Development Process refers to the entire range of activities where a company conceptualizes and realizes a new offering. A product concept might originate in the marketplace, or in a lab or workspace, or in the so-called fuzzy front end. Ideas come from customer requirements, too.

New product development usually follows a process divided into stages, phases or steps, by which a company conceives a new product idea and then researches, plans, designs, prototypes, and tests it, before launching it into the market. Below we will discuss the phases of new product development some product development examples (if you want to see a lot more examples, see our product development strategy page).



Product Development Process – 6 Steps

The product development process is the specific series of steps or stages a company uses to achieve its realization of new offerings to satisfy a market need. While nearly every company develops new products or services, product development techniques differ substantially from one company to another depending on the industry, the product type, whether the products are an incremental improvement or a breakthrough innovation. This is probably the most impactful form of process management that a company can undertake, besides managing the product life cycle itself.

In many cases, since organizations rarely focus on this, a product management consulting engagement or a product development consulting engagement can provide the right kind of outside guidance – especially if the gains are in the front end of development.

An accepted approach for more than three (or more!) decades puts a new product idea through a process that defines the stages of the new product process. These steps culminate in an up-or-down decision made by the Senior Management team in a formal review (often called a "gate") at the end of each phase. At the end of the product development state is often a commercialization stage (physical products) or QA stage (software). Note, this assumes that you have a staged development process and are not following the agile methodology.

6 STEPS OF THE NEW PRODUCT DEVELOPMENT PROCESS [NPD]

We will start with a description of the steps to explain the new product development process. A typical product development process has 6 steps with five gates.

- **Step 1: Idea Generation (Ideation)**
- **Step 2: Product Definition**
- **Step 3: Prototyping**
- **Step 4: Detailed Design**
- **Step 5: Validation/Testing**
- **Step 6: Commercialization**

1. Idea Generation (Ideation)

This first step or stage of the Product Development process, often called "Ideation," is where new product concepts originate. Often this step is a result of an idea screening to select the next product effort, and is more clearly defined in new product development. Following best practices, businesses form a small team to explore the product roadmap and perform…

- The initial definition of the product concept

- Business analysis (including SWOT analysis)
- Market research
- Technical and market risk

The idea stage is often the most important step for brainstorming new products because it is where most product ideas come from. Sometimes a SWOT analysis (strengths, weaknesses, opportunities and threats) analysis is used as a vehicle to prioritize ideas in this first step.

From Idea, To Concept, to MVP

Often product development starts out with a product manager realizing that the sales are lagging their forecasts because it is late in the product life cycle. The manager wants to act, but sometimes they lack a methodology. Other times the motivation is that someone in engineering (or sales) comes up with a bare idea out of the blue, not driven by the product development cycle (not all products come from product managers!), but because of some independent brainstorming. Finally, it can come out of a deliberate marketing strategy and product roadmap.

Product Management and Idea Screening Stage

One of the key responsibilities of a product manager is to screen ideas so the product development team does not waste time pursuing product concepts that fail. There are many factors that go into idea screening: customer feedback, social media monitoring, as well as fit to strategy and distribution/customer set. When you are refining existing products, or are in a prototyping phase, the product manager has the added capability to get more specific and directive feedback for the product development team because these are more tangible.

In all cases, product managers need to turn a product idea into a concept. Once you have a concept firmly in mind, you can think about concept development and testing with prospective customers to make sure you are on the right course (this is especially true when you have come up with an entirely new idea or new market). If the concept is super simple, you could even go directly to a Minimum Viable Product (MVP) and start getting real feedback.

Getting the product concept wrong at this early stage wastes time and increases opportunity cost. Note not all new product ideas come from the inside – the Corporate Development organization and executives should be constantly scanning for new product ideas. Marketing efforts should also including active competitive analysis and market scanning. Engineering should be brainstorming, too.

It is at this stage where the target market, target audience (including Personas) and target customers are proposed, and the initial marketing strategy is worked out. If the product goes through distribution, then the distributors are included as customers in this ideation step. Idea screening is performed in this phase.

2. Product Definition (Discovery)

Sometimes called “scoping,” or concept development, this step involves refining the definition of the product concept and ensuring that the team really understands customer requirements. In a startup this step is often called Discovery. The design team is assembled in this phase. The team creates the first detailed assessment of the technical, market and business aspects of the new product concept and determines core functionality. A template, or approach, for design thinking might be useful in getting started.

Sometimes mockups are used to obtain early feedback on product market fit. These mockups can be primitive, for example paper prototypes are commonly used to get early feedback from test marketing. If this is an incremental product, then concept design can begin. For breakthrough products, the team may consider simulations to get user feedback. The newer the product

category is to the company, the more concept testing is required. The basic goal of product discovery techniques is to ensure that the ideas are good and will satisfy customers.

Concept design often begins in this phase. The design team can begin to visualize the end product and can communicate this to potential customers (in software, this simpler than in a complex system or hardware product).

Marketing Strategy Development

Developers and managers explore and define the key points of differentiation for the new product. This step in development, if done improperly, can increase time to market or cause the product to misunderstand the needs of the market. Because this step is often before really ramping up the team, the alignment with the product development strategy is also very important. Although it is early, often metrics such as ARR (Annual Recurring Revenue) or Acquisition Costs are estimated. Clearly a product roadmap can be instrumental in guiding (or developed with) the marketing strategy.

Business Analysis

After the first stage of development, business analysis is performed. The team would look at similar products, perform a competitive analysis, and begin to map out the distribution strategy, including ecommerce. This is done to ensure the margins returned to the firm will meet thresholds. The market strategy will also guide the estimates of advertising and PR, again which weigh into the ROI calculation for the new product. Often a three year Profit and Loss plan is part of the business analysis.

Development Costs

As part of the business analysis, and with an understanding of the product definition, the team can develop estimates of development costs at this stage of the development cycle. This cost also goes into the business analysis in order to calculate ROI or IRR metrics.

3. Prototyping

In this prototyping phase) (or step) in the product development process the team justifies the company's investment in the development of a product by requiring the team to create a detailed business plan. Best practices usually involve intensive market research and a clear project management approach. The team thoroughly explores the competitive landscape for the new product and where the proposed product fits within it, while also creating a financial model for the new offering that makes assumptions about market share. Besides concept testing, pricing is determined in this step.

For tangible new products, such as hardware or mixed systems, the team also considers the manufacturability of the proposed new product, and this includes the sourcing of the product if out sourced. By the end of this phase, Senior Management should have a clear idea of what they're investing in and how it will perform in the marketplace.

This third step in the product development process (the prototyping phase) is critical because it reduces the market risk for the new product. This is the stage where you can perform test marketing because of the existence of prototypes that you can show to customers and get initial feedback. Software development can do these tests earlier because of the relative ease of creating realistic user interfaces. In this stage, the initial design work would show technical feasibility.

4. Detailed Design

In this phase, the focus is on product design but also refinement of the prototype of the product. In most cases teams alpha-test the prototype, working with customers in an iterative fashion: getting their feedback and incorporating it into the prototype. In parallel, marketing, sales and manufacturing begin to create the launch and manufacturing platforms to support the emerging

product. This fourth step in the product development process is sometimes called Development, and sometimes incorporates the next step, "Validation/Testing."

5. Validation and Testing

Validation and testing means ensuring the prototype works as planned. It also means validating the product in the eyes of the customers and markets, while testing the viability of the financial model for the product. At this stage, the finished product may be available for initial feedback from paying customers.

Everything in the business case, and everything learned from customers during the Development phase comes under scrutiny and is tested in "real world" conditions as much as possible. The marketing strategy is also confirmed at this point. If anything in the business case or prototype needs revising, this is the team's last chance to do so. This is the last step before the final product is ready for the market. Often test marketing, or beta testing (depending on the type of product), is performed at this stage to help validate the go to market plan.

6. Commercialization

During this step of the product development process (including the manufacturing process), the team realizes everything required to bring the final product to market, including marketing and sales plans (or sales training if necessary) for the market introduction. The finished product will be built (or released in the case of software) and be able to be sold after final testing. The team, including project management, begins to operationalize the manufacture and customer support for the product and supports the product introduction. That is why this step is called the Commercialization Phase. Test marketing may continue to enable the company to have the greatest success with the launch.

12 STAGES OF PRODUCT DEVELOPMENT PROCESS

1. **Idea Generation:** The first stage in the product development process is idea generation. In this stage, the company comes up with many different and unique ideas based on both internal and external sources. Internal idea sources more often than not refer to the in-house research and development teams of the company and external sources refer to competitor innovations, the customer wants, distributors and suppliers, and so on. The company thereby focuses on coming up with as many feasible ideas as possible.
2. **Idea Screening:** The next stage involves the screening of this often-large set of ideas. The primary objective of this stage is to focus on ideas that are in line with the company's customer value and financial goals. The stage focuses on the filtering out of ideas that are poor or are not feasible and retaining those that have good potential. This is to ensure that the company does not face losses by moving ahead with fickle ideas that do not promise adequate returns.
3. **Concept Development and Testing:** The third of the product development process steps is concept development and testing. In this stage, good product ideas must be developed into detailed product concepts that are conveyed in consumer-oriented terms. The concept must be made in order to protect the product in terms of how it is perceived by consumers and how it will potentially be received in the market and by which set of potential customers. This concept must then be tested by presenting it to the target consumers and their response must be taken into account.
4. **Development of Marketing Strategy:** The new product development process in marketing is covered in stage four. In this step, the company tries to come up with strategies to introduce a promising product into the market. The company must therefore

come up with the price, and potential revenue figures as well as advertising and distributing channels in this step.

5. **Business Analysis:** The product concept is put through a vigorous business analysis or test in order to ascertain projected sales and revenue and also assess risk and whether the production of the product is financially feasible. The company's objectives are considered and if these are satisfied, the product is moved on to the next step.
6. **Product Development:** This is the step that comes after the management of a company declares a product concept to be in line with the goals of the company and issues green light for development. The research and development wing of the company then works on the product concept for many months and even years in some cases, to come up with a working and functional prototype of the product concept.
7. **Test Marketing:** This is the penultimate stage of the new product development process and involves the testing of the product and its suggested marketing program in realistic market settings. This stage provides an insight into how the product will be introduced into the market, advertised, produced, packaged, distributed, and eventually sold to the customers, and therefore any optimizations if required can be made by the company.
8. **Commercialization:** The final step of the product development process is that of commercialization. Based on the information gathered during the test marketing process, the business management may either decide to go ahead with the launch of the product or put it on the backburner. In case the go-ahead is given, the product is finally introduced into the market and this process is called commercialization. This stage often leads to massive costs in terms of initial infrastructural investments as well as sales promotions and advertisements.
9. **Research:** At this point, there are two vital things to look into: First and foremost, is there a demand for the service or product. Are there many people seeking a solution to the problem that your product solves? Do you notice a void that needs to be filled? Second, are there any products identical to yours existing on the market? If this is the case, it doesn't necessarily rule out the possibility of your idea becoming a success; nevertheless, how will you improve on what is already available?
10. **Computer-aided design:** Nowadays, computer-aided design is essential for the new product development process. This technique creates a computer simulation of your final design using 3D rendering software. This can help uncover any possible difficulties that were not obvious from the product design. Take advantage of this opportunity to return to the final design stage and address any issues.
11. **Computer-aided manufacturing and Prototype Evaluation:** This is where you may witness a tangible prototype of your product that was created using a computer-aided manufacturing system. A thorough review is required for every **product development process**. Make sure that your testing is rigorous and thorough. Don't be afraid, to be honest with yourself about any design defects or problems since this will only help your final product be the best. Return to step 3 if necessary to iron out the kinks.
12. **Manufacturing and assembly:** It's time to produce your product if you made it through prototype testing without any issues that need to be addressed. There may be other selections to be made here, such as materials, packing lists, and the manufacturer. Consider how to keep prices low while keeping the quality you desire in order to maximize revenues.

At this point, you may need to make some important decisions on additional materials. Keep prices in consideration, but keep in mind that employing ineffective materials could hurt your sales. Don't jeopardize the quality of your work by cutting corners today.

The Best Product Management Tools List

1. monday.com – **Best for scalability**
2. Walling – **Best for visually organizing project ideas and tasks**
3. airfocus – **Best modular product management software**
4. QA Wolf – **Best for companies where web-applications are their main product**
5. Craft.io – **Best product feature prioritization engine**
6. Dragonboat **– Best for connecting product development to OKRs**
7. ProdPad – **Best product lifecycle management tools**
8. Productboard – **Best product development with customer research**
9. ProductPlan – **Product development software with beautiful UI**
10. Roadmunk – **Popular roadmap tool to visualize product strategy**

Criteria For Selecting Product Management Tools

What are we looking for when we select the best tools for review? Here's a summary of my evaluation criteria:

1. **User Interface (UI):** Does the app have a clean, intuitive, and modern-looking user interface across different operating systems, including mobile and PC variants.
2. **Usability:** How steep is the software's learning curve? Does it offer adequate customer support across different mediums (phone, chat, email, etc.)? Do they have the training, certificates, blogs, webinars, or other materials to assist learning?
3. **Features & Functionality:**
    - **Task Management –** Does the tool have a way to manage and organize product-specific tasks? Is the task navigation solution suitable for product development and product testing?
    - **Idea Capturing / Roadmaps –** Not every feature is a "must-have" right away so any good product management tool should carve out some space to keep functionality wishlists and brainstorming results.
    - **Product Spec Templates** – Does the product management system have product spec templates for easy storage of functional details, files, and discussions?
    - **Customer Feedback Aggregation** – Does the tool capture customer (or even in-team) feedback through sources like email, support chat, browser-based help tools, and CRM integrations? Does the said tool compile the feedback into highly readable and actionable results?
4. **Integrations:** Does the product management tool have an apps marketplace or other way to connect with first- and third-party apps to unlock additional features?
5. **Value for $:** How appropriate is the price for the features, capabilities, and use case? Is pricing clear, transparent, and flexible?

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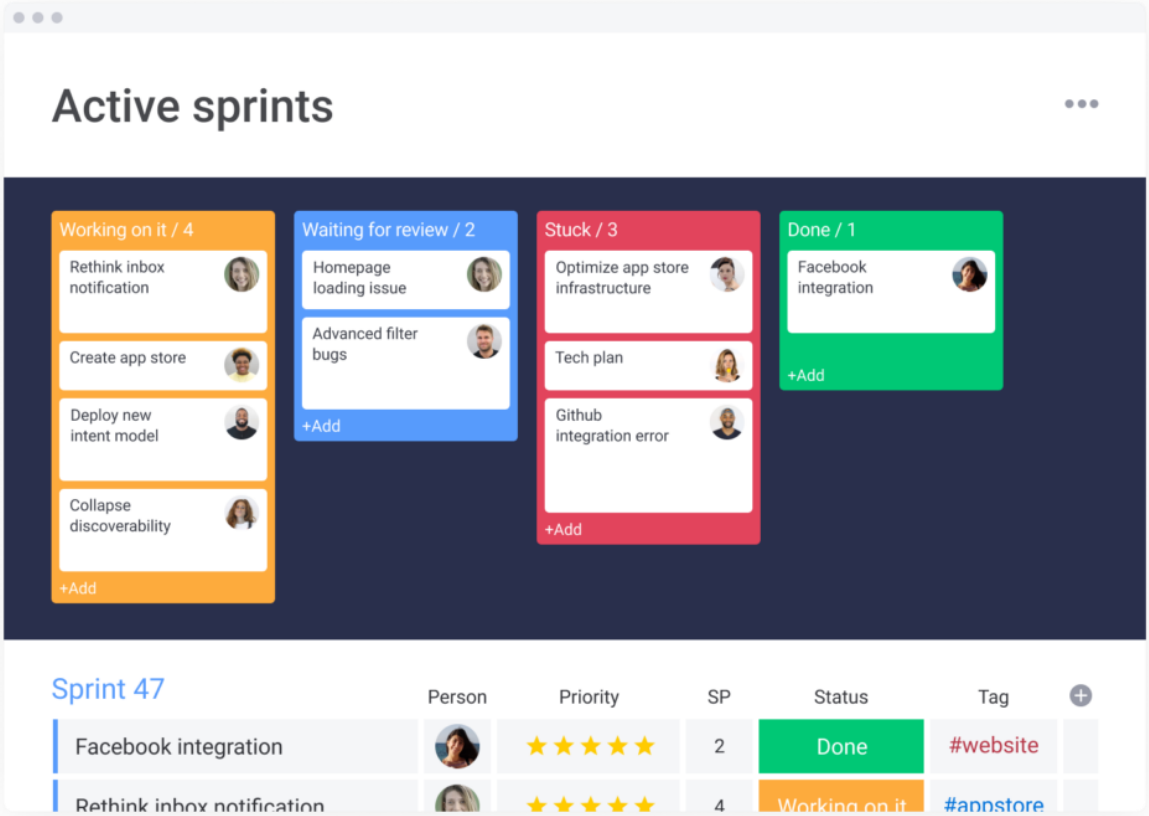
OVERVIEWS OF THE 10 BEST PRODUCT MANAGEMENT TOOLS

1. monday.com – Best for scalability



Simple board Kanban Software development Active Sprints.

monday.com is an online product management platform that enables teams of all sizes to plan, track, and manage their daily work. From large scope product roadmaps to weekly iterations, monday.com helps teams define clear ownership, analyze and track their work, manage sprints, and collaborate together. monday.com's easy-to-use agile platform makes it simple for teams to work together from anywhere.

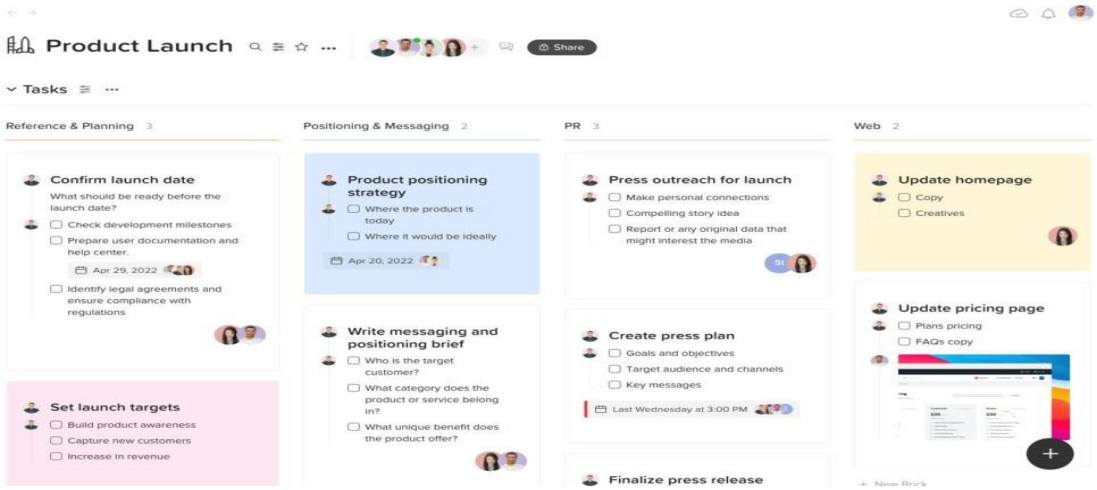
monday.com's Work OS is built from visual and flexible features that come together to create any agile workflow your team needs. It supports milestones, Gantt and Kanban views, task dependencies, and project analysis.

monday.com has a simple and intuitive UI, and onboarding is quick and efficient. Teams in any department can easily find the features they need to customize their account to fit their needs. monday.com also offers 24/7 support, recorded webinars and tutorials, and thorough Knowledge Base articles to ensure teams always have answers to their questions.

monday.com has customizable templates for any team or stage of product management. Use the template as is, or customize by adding column types (such as numbers for calculations, deadline, rating, and more) or switching between views (such as Kanban, Gantt, calendar, and more). monday.com's flexible scrum platform provides value to managers and can support teams with anywhere from 5 to 5,000 members.

monday.com has integrations with 40+ tools which allow a 2-way sync of data. Within monday.com, sales teams can import their lead data from Salesforce, marketing teams can update campaign information in Hubspot, and R&D teams can manage anything through GitHub.
Pricing for monday.com starts from $17/2 users/month. The tool offers a 14-day free trial.
Visit Website

2. Walling – Best for visually organizing project ideas and tasks



With Walling, your ideas and tasks are visualized side by side in one place.

Walling is one of the most visual product management platforms that enables you to organize and manage ideas and tasks within a clean interface.

Walling helps product managers and teams get organized and manage their projects by giving them one place that provides clarity on all their project tasks, ideas, and important information. It comes with features that let you collect ideas and organize them in one visual place along with the project tasks.

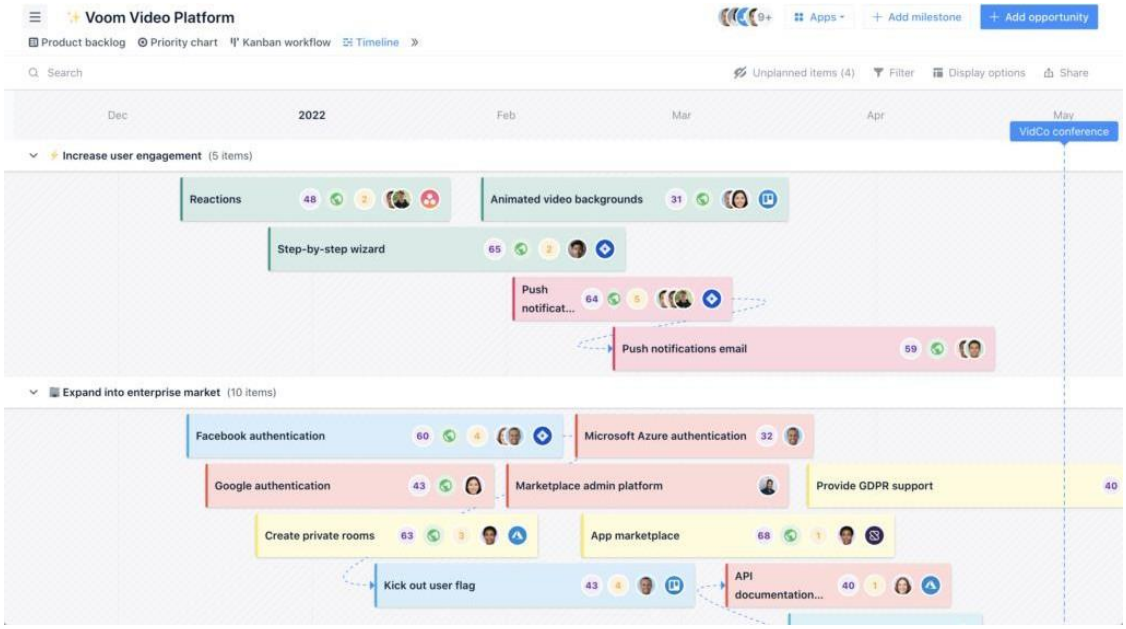
What makes Walling stand out is that it enables you to organize tasks, ideas, notes, and files side by side to empower you to see the big picture of your work. The tool has a variety of views such as the Kanban view, task lists, calendar and database tables. Walling's collaboration features include adding comments, assigning tasks and adding due dates and reminders.

Walling integrates with Google Drive and it has a list of other third-party integrations planned for later down the road.

Walling offers a free plan for up to 100 bricks. Paid plans cost from $5/user/month.

Visit Website

3. airfocus – Best modular product management software



Share lean roadmaps that update in real-time as the product development progresses.

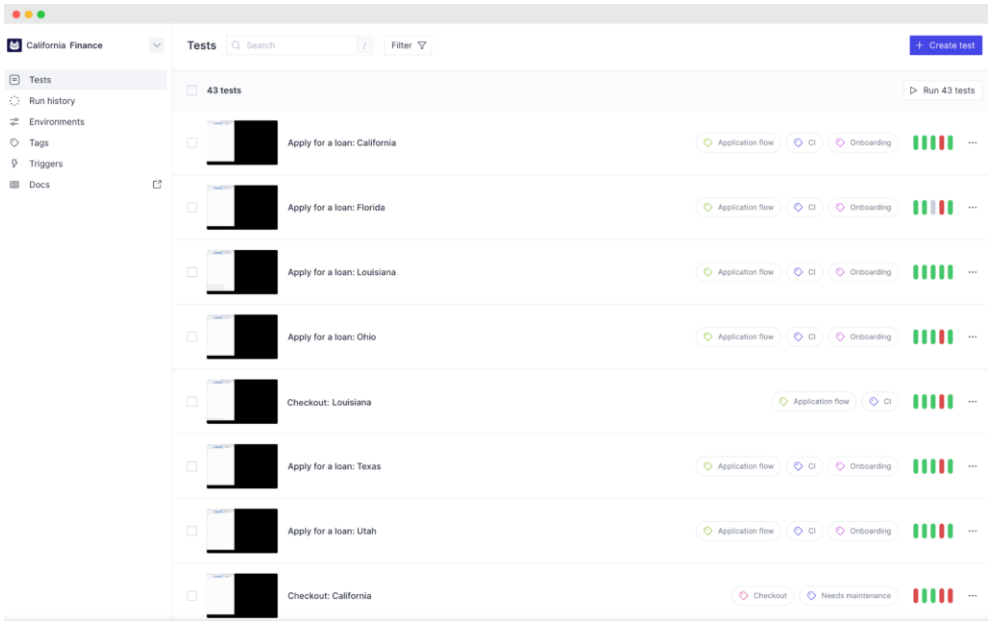
airfocus is the market's first and only modular product management platform, specifically tailored for product teams to manage market-facing products, internal products, IT portfolios, and more. The flexible platform helps product teams manage strategy, understand user needs, prioritize, and align their teams around clear roadmaps.

airfocus users can set up their roadmaps quickly with the intuitive drag-and-drop interface and use the library of fully adjustable templates built on proven product management and roadmapping methods.

airfocus stands out in its ability to rate and rank each initiative and feature of your product based on customizable scoring criteria that users can input themselves. This capability will uniquely service product management teams who struggle with stable priority rankings.

Integrations include Jira, Trello, Asana, Azure DevOps, Shortcut, Microsoft Planner, GitHub, Intercom, Google Chrome, and hundreds more through Zapier.
airfocus starts from $15/month and offers a 14-day free trial.
Visit Website

4. QA Wolf – Best for companies where web-applications are their main product



A sample of a QA Wolf user story testing dashboard.

QA Wolf is a product management tool for product teams at SaaS companies that want to go to market faster by ensuring new software features are bug-free.

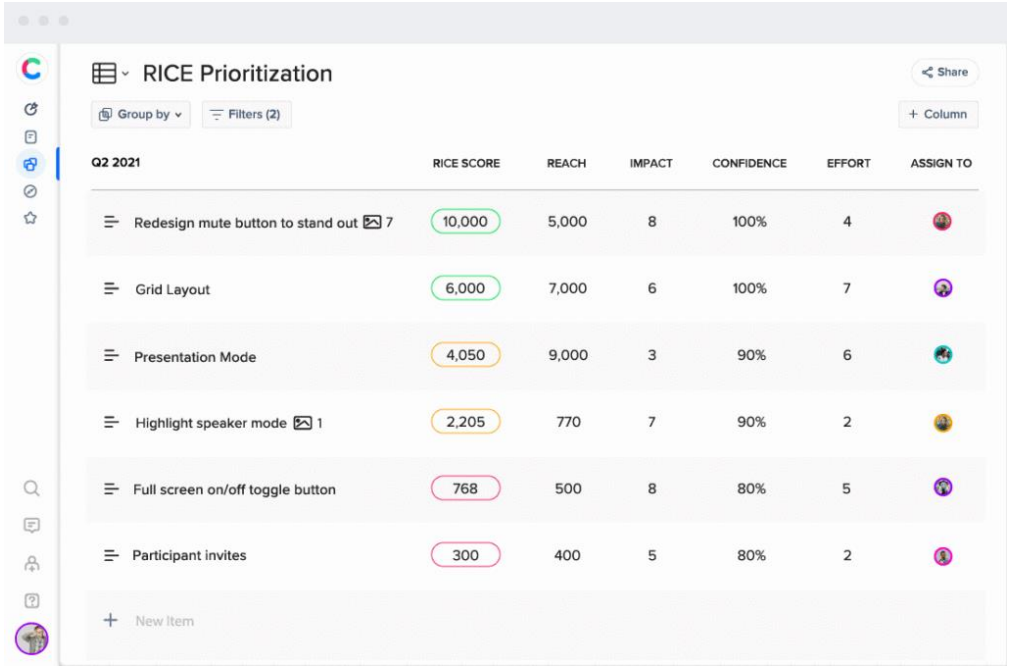
QA Wolf helps get teams to 80% automated test coverage in about 3 months. Conversely, traditional QA teams/tools either take years to get to 80% test coverage or simply never get there. To add to that, QA Wolf demands low effort. They create test matrices for clients and think critically on their behalf. QA Wolf proactively creates new tests and ensure they're always at the 80% coverage benchmark.

QA Wolf also analyzes data and synthesizes findings so product managers immediately know what went wrong instead of having to investigate themselves while other tools/services require you to be prescriptive and closely manage testing. QAWolf is also affordable. They only charge for coverage and not for hours worked, making it so that using QA Wolf is only half the price of a QA Engineer.

Notable features of QA Wolf include: unlimited tests and test runs, full web application testing, no vendor lock-in, and 100% parallelization.

QA Wolf integrates with CI/CD.

5. Craft.io – Best product feature prioritization engine



Craft.io's unique prioritization item lets you score tasks and features according to RICE score (reach, impact, confidence, effort) to easily determine the best next steps anywhere in your development pipeline.

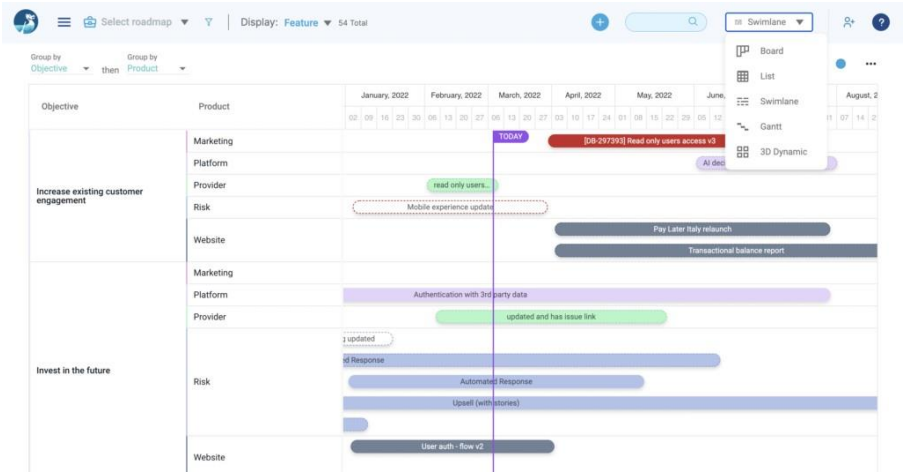
Craft.io is a product management platform that comes with features for feedback capturing, workflow planning, and roadmapping. On the platform, you can define product specs, prioritize and share key decisions, and manage workload capacity.

Through integration and collection of fragmented product data, Craft.io is your complete product system of record. It tracks all product information from stakeholder and team member feedback to strategy documentation of OKRs, personas, and themes.

Craft.io is also packed with sharing and collaboration features, various roadmap views, status monitoring, as well as customizable and shareable ways to view your data.

Craft.io integrates with Pivotal Tracker, Azure DevOps, Jira, GitLab, Github, Targetprocess, Intercom, Dropbox, Okta, Google Workspace, Active Directory, SAML, Google Drive, and Ping Identity. More integrations are available via a paid plan through Zapier.

6. Dragonboat – Best for connecting product development to OKRs



Dragonboat connects your desired outcomes and goals directly to ongoing product development and resource allocation systems.

Dragonboat is a comprehensive, user-friendly product portfolio management platform for outcome-focused teams. Connecting OKRs, customer feedback, and roadmaps, Dragonboat offers integrated product planning, resource forecasting, automated tracking, and dynamic stakeholder reporting.

With Dragonboat, product managers can centralize feedback and requests, prioritize features and build Stakeholders can follow along with permission-controlled roles as Reader or Editor.

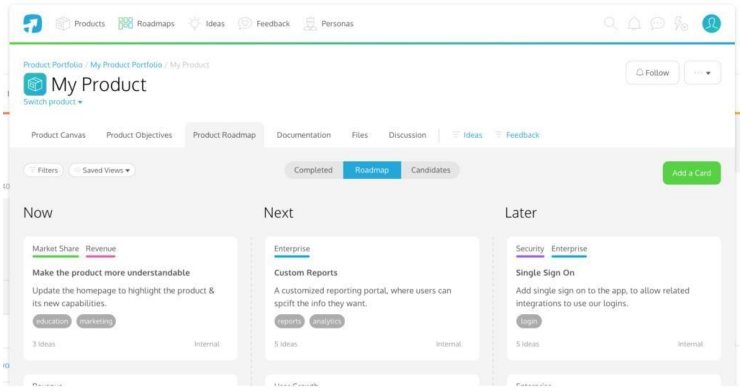
Dragonboat lets you set resource allocation towards objectives and key results (OKRs) and other initiatives. This way, you can track the direct ROI of new product features and updates to ensure you are using your team's time effectively.

Dragonboat integrates with Jira, Clubhouse, Azure DevOps, Asana, and Github.

Dragonboat costs from $39/user/month and comes with a free demo. They have a free plan for single users and startups; contact their team for details.

Visit Website

7. ProdPad – Best product lifecycle management tools

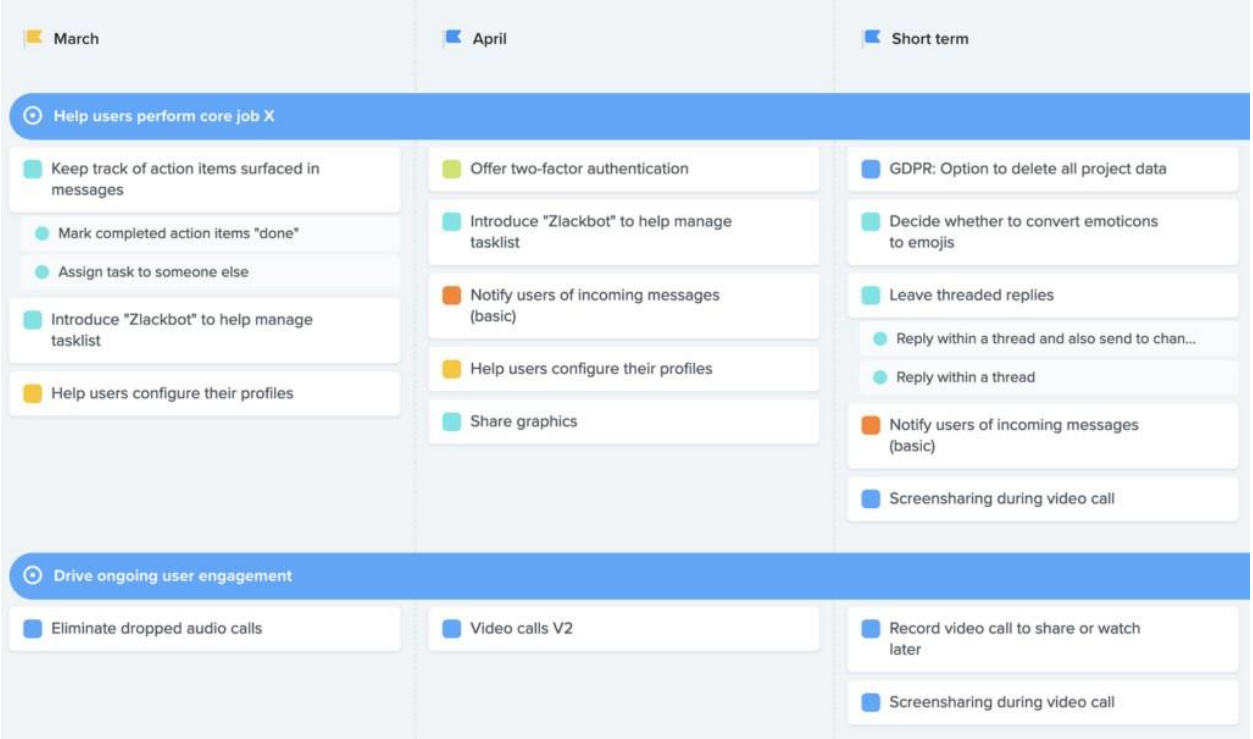


Design product-specific goals organized by current (urgent) and future (roadmap) planning.

ProdPad is a lean product roadmap tool that keeps everyone on your team informed and aligned. Product management gurus will appreciate features such as product spec templates, annotated designs and versioning, and realistic user personas.
Some users might struggle with ProdPad's browsing and search capabilities, which are not nearly as streamlined as they could be (good luck hunting for that "one" important item in your ideas bank). Regular clean-up and internal naming conventions can ease this pain.
Integration include Slack, Trello, Jira, Active Directory, Azure DevOps, Confluence, Doorbell.io, Dropbox, GitHub, Google Apps, Pivotal Tracker, Rally, TFS, UserVoice, and over 1000 more options with a connection through Zapier.
ProdPad spends considerable effort on ensuring their planning, ideas, and roadmaps solutions are strong; they meet and exceed what I am looking for when I list Idea Capturing as a must-have in the product management tools review criteria outlined above.
ProdPad costs from $99/month and has a free 7-30 day free trial (see: their "free trial" rewards system).
Visit Website

8. Productboard – Best product development with customer research

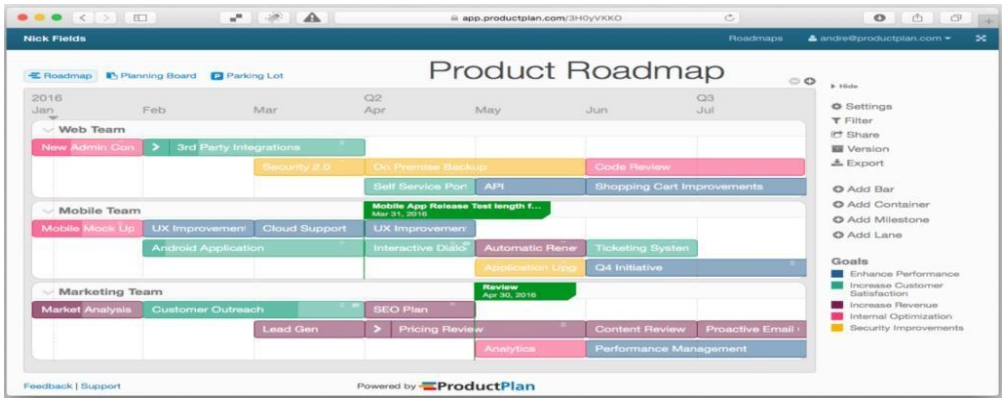
Product tasks can be divided into short term and long term deadlines and arranged in boards.



Used by the likes of Microsoft and Zendesk, Productboard is a product management system that helps your team understand what target users need, prioritize what features to build (and when), and unify everyone from planning to QA around your product roadmap.
One of the things I looked for in my review was the depth and breadth of third-party integration options with popular project management tools. While Productboard has a handful of integration options, a slight downside is that their available connections are fewer than most on this list.
Integrations include Slack, Intercom, Zendesk, Gainsight, Trello, Jira, Pivotal Tracker, and GitHub.

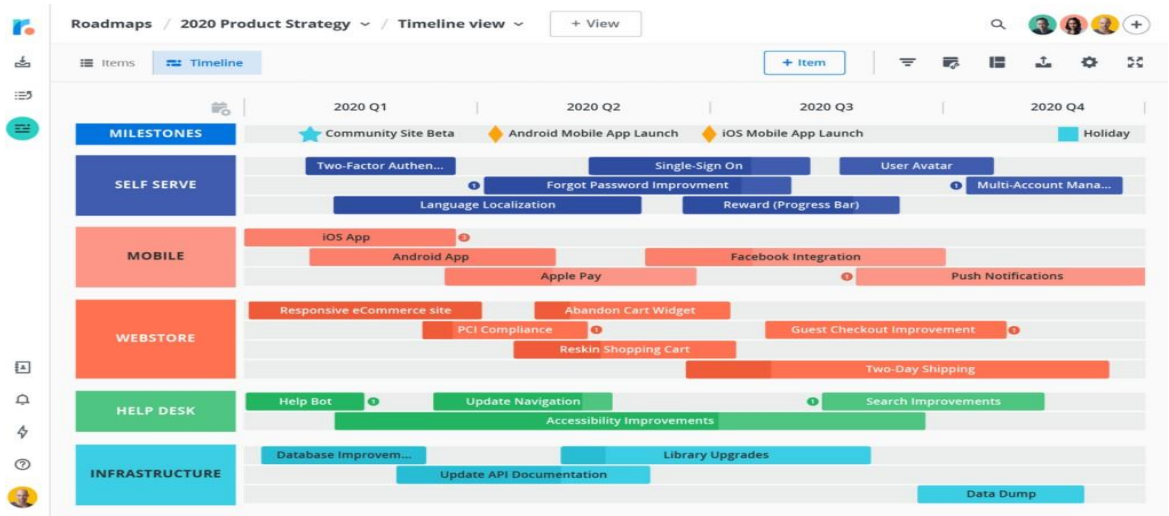
Productboard does a lot of things well but one thing in particular that stood out is the usefulness for being able to aggregate product insights and customer requirements/requests across multiple inboxes, including slack. If an ongoing product feedback loop is important to you, Productboard will stand out.

9. ProductPlan – Product development software with beautiful UI



Design a product roadmap from start to finish using Gantt chart visuals and color-coded goals.
Used by HubSpot and Coca-Cola, ProductPlan is an easy way to plan, visualize, and communicate a product strategy using 25+ roadmap templates,
Despite the strong features list above, ProductPlan is missing an adequate way to handle requirement management for the products they host. For many users, this won't be an issue as requirements are often handled separately; however, it's a good thing to keep in mind.
Integrations include Jira, GitHub, Slack, PivotalTracker, Trello, Azure DevOps, Confluence, and Microsoft Teams. More options are available using the ProductPlan REST API.
Something I highlight as important in the review criteria for product management tools is an available selection of product spec templates. ProductPlan is great for this, as they not only have product roadmap templates but also offer templates for launch plans, executive-facing portfolios, OKRs, IT strategy, and more.

10. Roadmunk – Popular roadmap tool to visualize product strategy



Roadmunk is an end-to-end, customer-driven roadmapping tool used by the likes of Amazon, Xero, and Slack. Product managers will value being able to capture customer feedback, prioritize what to build, and design boardroom-ready strategy roadmaps.
Some tricky formatting and coloring options require design intervention that prevents Roadmunk reports from being appropriate in an executive boardroom straight off the app. While this may be considered an inconvenience to some, most users won't even notice.
Integrates natively with Jira and also offers a Roadmunk API powered by GraphQL for further self-lead integration options.
Customer feedback aggregation is a product management tool trait that I specifically call out in the evaluation criteria due to its importance for the development cycle. Roadmunk understands this more than most and scored favorably in its ability to manage all user requests in one organized place (their "feedback inbox" feature).

Process Design

WHAT IS PROCESS DESIGN?

At the start of the process design activity it is important to understand the design objectives, especially at first, when the overall shape and nature of the process is being decided. The most common way of doing this is by positioning it according to its volume and variety characteristics. Eventually the details of the process must be analyzed to ensure that it fulfils its objectives effectively.

Process design and service/product design are interrelated

Often we will treat the design of services and product, on the one hand, and the design of the processes which make them, on the other, as though they were separate activities. Yet they are clearly interrelated. It would be foolish to commit to the detailed design of any product or service without some consideration of how it is to be produced. Small changes in the design can have profound implications for the way the operation eventually has to produce them. Similarly, the design of a process can constrain the freedom of product and service designers to operate as they wish. This overlap is greatest in in operations which provide services. (see figure 4, page 98)

WHAT OBJECTIVES SHOULD PROCESS DESIGN HAVE?

The whole point of process design is to make sure that the performance of the process is appropriate for whatever it is trying to achieve. Operations performance objectives translate directly to process design objectives (see table 4, page 99). But, because processes are managed at a very operational level, process design also needs to consider a more 'micro' and detailed set of objectives. These are largely concerned with flow through the process. Because of time spend in inventories and waiting to be transformed by the next activity the time a unit spends in the process (throughput time) will be longer than the sum of all the transforming activities that it passes through. Also the resources that perform the process's activities may not be sued all the time because not all items will necessarily require the same activities and the capacity of each resource may not match the demand placed upon it.
Throughput rate = the rate at which items emerge from the process, the number of items passing through the process per unit of time Cycle time = the time between times emerging from the process Throughput time = the average elapsed time taken for inputs to move through the process and become outputs Utilization of process resources = the proportion of available time that the resources within the process are performing useful work.
Standardization of processes One of the most important process design objectives concerns the extent to which process designs should be standardized. By standardization in this context is meant 'adopting a common sequence of activities, methods and use of equipment'. It is a

significant issue in large organisations because very often different ways of carrying out similar or identical tasks emerge over time in the various parts of the organization. The problem is that allowing the numerous ways of doing things causes confusion, misunderstandings, and eventually, inefficiency. The practical dilemma is how to draw the line between processes that are required to be standardized, and those that are allowed to be different.

Environmental sensitive process design

With the issues of environmental protection becoming more important, process designers have to take into account 'green' issues. In many developed countries, legislation has already provided some basic standards. Interest has focused on some fundamental issues: • The sources of input to a product or service • Quantities and sources of energy consumed in the process • The amount and type of waste material that are created in the manufacturing processes • The life of the product itself • The end-of-life of the product

Designers are faced with complex trade-offs between these factors, although it is not always easy to obtain all the information that is needed to make the 'best' choices.

Life-cycle analysis = analyses all the production inputs, the life-cycle use of the products and its final disposal, in terms of total energy used and all emitted wastes. The inputs and wastes are evaluated at every stage.

PROCESS TYPES – THE VOLUME-VARIETY EFFECT ON PROCESS DESIGN

Processes range from those producing at high volume to low volume. Also processes range from producing very low variety of products and services to a very high variety. Usually the two dimensions of volume and variety go together – but in a reversed way. So low-volume processes often produce a high variety of products and services.

Process Types

The position of a process on the volume-variety continuum shapes its overall design and the general approach to managing its activities. These 'general' approaches to designing and managing processes are called process types (see figure 4, page 102).

Project processes Project processes deal with discrete, usually highly customized products; often with a relatively long timescale between the completion of each item, where each job has a well-defined start and finish. Project processes have a low volume and high variety. Activities involved in the process can be ill-defined and uncertain. Transforming resources may have to be organized especially for each item. The process may be complex, partly because the activities in such processes often involve significant discretion to act according to professional judgment.

Jobbing processes Jobbing processes also deal with high variety and low volumes. However, while in project processes each item has resources devoted more or less exclusively to it, in jobbing processes each product has to share the operation's resources with many others. Resources will process a series of items but, although each one will require similar attention, they may differ in their exact needs. Many jobs will probably be 'one- offs' that are never repeated. Jobbing processes could be relatively complex; however they usually produce physically smaller products and, although sometimes requiring considerable skills, such processes often involve fewer unpredictable circumstances.

Batch processes

Moving off the natural diagonal A process lying on the natural diagonal of the matrix will normally have lower operating costs than one with the same volume-variety position that lies of

the diagonal. This is because the diagonal represents the most appropriate process design for any volume-variety position. Processes that are on the right of the diagonal would normally be associated with lower volumes and higher variety. This means they are likely to be more flexible than seems to be warranted by their actual volume-variety position. They should be more standardized, which means their costs are likely to be higher than they would be with a process that was closer to the diagonal. Conversely, processes on the left of the diagonal have standardized to much which can also lead to high costs.

DETAILED PROCESS DESIGN

After the overall design of a process has been determined, its individual activities must be configured. At its simplest, this detailed design of a process involves identifying all the individual activities that are needed to meet the objectives of the process, and deciding on the sequence in which these activities are to be performed and who is going to do them. There will be some constraints to this.

PROCESS MAPPING

Process mapping simply involves describing processes in terms of how the activities within the process relate to each other. There are many techniques which can be used for process mapping. However, all the techniques identify the different types of activity that take place during the process and show the flows of materials or people or information through the process.

Process mapping symbols Process mapping symbols are used to classify different types of activity. And although there is no universal set of symbols used all over the world for any type of process, there are some that are commonly used (see figure 4, page 110). These symbols can be arranged in order, and in series or in parallel, to describe any process.

Different levels of process mapping For a large process, drawing process maps at this level of detail can be complex. This is why processes are often mapped at a more aggregated level, called high-level process mapping, before more detailed maps are drawn. At the highest level the process can be drawn simply as an input-transformation-output process. No details of how inputs are transformed into outputs are included. At a slightly lower level or more detailed level, a line process map identifies the sequence of activities but only in a general way. A micro-detailed process map could specify every single motion involved in each activity.

Process visibility It is sometimes useful to map such processes in a way that makes the degree of visibility of each part of the process obvious. This allows those parts of the process with high visibility to be designed so that they enhance the customer's perception of the process. There are several levels of visibility, the boundary between the two categories medium visibility and low visibility is called the 'line of visibility'. The line between very high visibility and high visibility is called the 'line of interaction'. between very high visibility and high visibility is called the 'line of interaction'.

PROCESS – PLANNING & DESIGN:

- Process Meaning: A process is any part of an organization that takes inputs and transforms them into outputs.

- The value the process generates is the difference between what the final product is worth to the customer and its initial value.
- The objective of the process is to provide the maximum overall value to the customer in the product.

PROCESS PLANNING:

- Production Planning organizes the resources needed to make a product.
- Most products can be made by a number of different processes.
- For e.g: a table can be hand-built by craftsman's, it can be assembled from bought-in parts by semi-skilled people; it can be made automatically by machines on an assembly line; So, operations manager have to design a process that will make a product with the features described in the product plans.

Functions of process planning:

1. The process describes the operations used to make a product.
2. Process Planning makes the decisions about a process. It designs a process that make a product as effectively and efficiently as possible.

Steps in process planning:

1. Analyze the part print to get an overall picture of what is wanted.
2. Make recommendations to or consult with the product engineer on product design changes.
3. List the basic operations required to produce the part to the drawing or specifications.
4. Determine the most practical and economical manufacturing methods and the form of tooling required for each operation.
5. Devise the best way to combine the operations and put them in sequence.
6. Specify the gauging required for process.

PROCESS SELECTION:

- Process Selection refers to the way an organization chooses to product its good or services.
- It takes into account selection of technology, capacity planning, layout of facilities, and design of work systems.

- Process selection is a natural extension after selection of new products or services.
- An organization Process strategy include:

1. Make-or-Buy Decisions:
2. Capital Intensity:
3. Process Flexibility

PROCESS SELECTION DECISIONS

1. Processes by market Orientation:
   i) Make to stock (MTS)
   ii) Assemble to Order (ATO).
   iii) Make to Order (MTO).
   iv) Engineer to Order (ETO).

2. Processes as Production systems:

i) Project.
ii) Job shop.
iii) Batch production (Disconnected Line).
iv) Assembly Line.
v) Continuous Flow.

3. Processes and customer Involvement:
   i) Self Service:
   ii) Product Selection:
   iii) Partnerships:

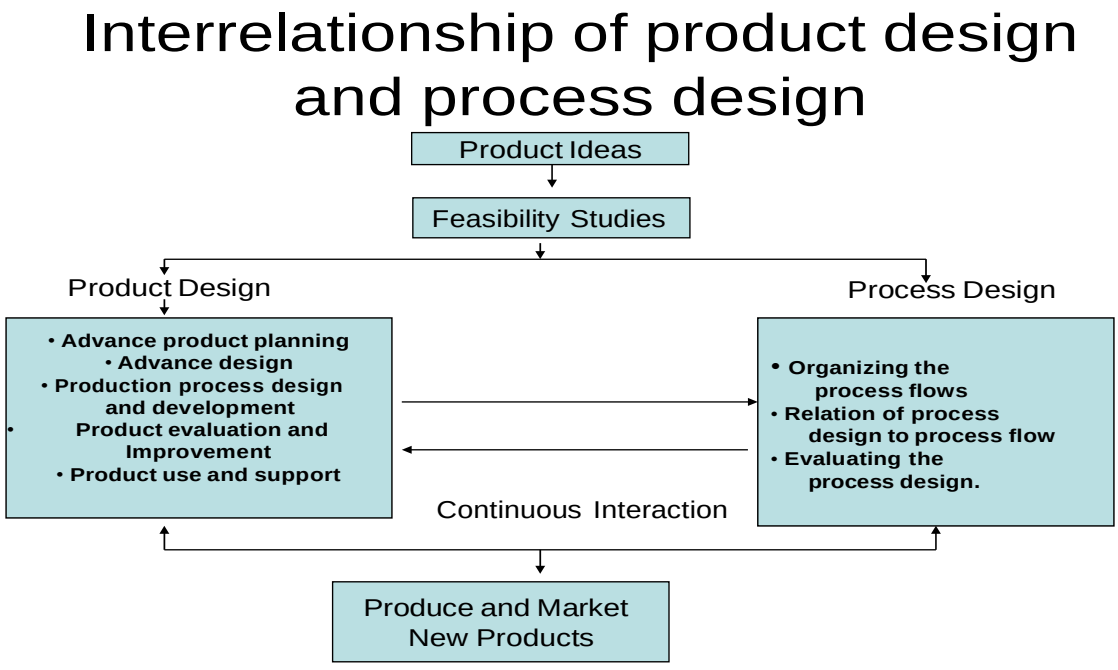
PROCESS DESIGN / STRATEGY

- Process design is concerned with the overall sequences of operations required to achieve the product specifications.
- It specifies the type of work stations that are to be used, the machines and equipment necessary and the quantities in which each is required.

- A Process strategy is an organization approach to transforming resources into goods and services.
- The main objective of strategy is to build such production process that meets customer requirements and specifications.
- The process strategies guide the process design.
- Process strategies are also termed as process design.

Types of process strategy / designs

1. Product- Focused System
2. Process- Focused System
3. Repetitive Focus System.
4. Mass Customized Focus
5. Group-Technology / Cellular Manufacturing System



Service Operations

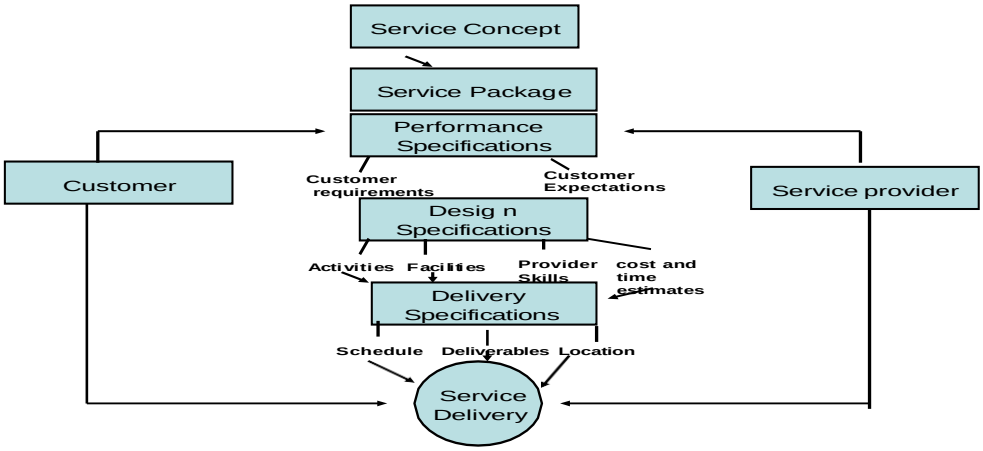
- Service design is the activity of planning and organizing people, infrastructure, communication and material components of a service, in order to improve its quality, the interaction between service provider and customers and the customer's experience.
- Three dimension of service design are:

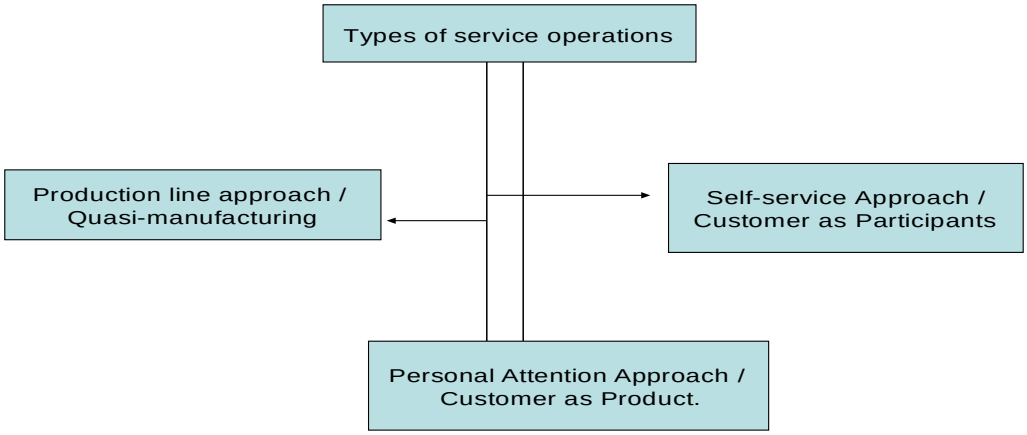
1. Degree of standardization
2. Degree of Customer Contact
3. Mix of goods and services

Stages in Service Operations / design

1. Service Concept
2. Service Package
3. Performance Specifications
4. Design Specifications
5. Delivery Specifications

SERVICE DESIGN PROCESS





Service Operations Strategies

- Customer – oriented focus
- Service – oriented focus
- Customer and service oriented focus

Examples: Fast food restaurants, petrol station, banks, airlines etc.

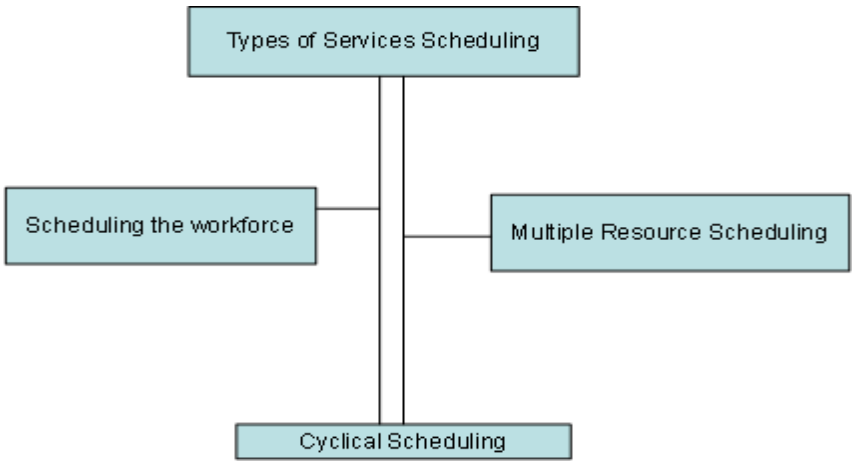
Scheduling service operations

1. Pricing and Promotion
2. Appointment and reservation Systems

i) Improving Appointment Systems:

- Provide economic incentives for showing-up
- Remind people of their appointments
- Penalize customers who arrive late, and do not reward Customers for arriving early
- Use wave schedules where appropriate

ii) Improving reservations systems



Scheduling the workforce

- Scheduling customers is demand management.
- Scheduling the workforce is capacity management.
- This approach works best when demand can be predicted with reasonable accuracy.

Multiple Resource Scheduling

- Resource allocation occurs in a multi-project environment where the demands of one project have to be reconciled with the needs of other projects.
- Organizations must develop and manage systems for efficiently allocating and scheduling resources across several projects with the different priorities, resource requirements, sets of activities and risks.

Problem in multi-project Scheduling

1. Overall Schedule Slippage: Overall schedule slippage, because projects often share resources, delays in one project can have a ripple effect and delay other projects.
2. Inefficient Resource Utilization: Inefficient resource utilization, because projects have different schedules and requirements, there are peaks and valleys in overall resource demands.
3. Resource Bottlenecks: Resource Bottlenecks delays and scheduling are extended as a result of shortages of critical resources that are required by multiple projects.

Cyclical Scheduling

Employees must be assigned to work shifts or time slots and have days-off, on a repeating or cyclical basis.

FACILITY LAYOUT - OBJECTIVES, DESIGN AND FACTORS AFFECTING THE LAYOUT

Introduction

For an organization to have an effective and efficient manufacturing unit, it is important that special attention is given to facility layout. Facility layout is an arrangement of different aspects of manufacturing in an appropriate manner as to achieve desired production results. Facility layout considers available space, final product, safety of users and facility and convenience of operations.

An effective facility layout ensures that there is a smooth and steady flow of production material, equipment and manpower at minimum cost. Facility layout looks at physical allocation of space for economic activity in the plant. Therefore, main objective of the facility layout planning is to design effective workflow as to make equipment and workers more productive.

Facility Layout Objective

A model facility layout should be able to provide an ideal relationship between raw material, equipment, manpower and final product at minimal cost under safe and comfortable environment. An efficient and effective facility layout can cover following objectives:

- To provide optimum space to organize equipment and facilitate movement of goods and to create safe and comfortable work environment.
- To promote order in production towards a single objective
- To reduce movement of workers, raw material and equipment
- To promote safety of plant as well as its workers
- To facilitate extension or change in the layout to accommodate new product line or technology upgradation
- To increase production capacity of the organization

An organization can achieve the above-mentioned objective by ensuring the following:

- Better training of the workers and supervisors.
- Creating awareness about of health hazard and safety standards
- Optimum utilization of workforce and equipment
- Encouraging empowerment and reducing administrative and other indirect work

Factors affecting Facility Layout

Facility layout designing and implementation is influenced by various factors. These factors vary from industry to industry but influence facility layout. These factors are as follows:

- The design of the facility layout should consider overall objectives set by the organization.
- Optimum space needs to be allocated for process and technology.
- A proper safety measure as to avoid mishaps.
- Overall management policies and future direction of the organization

Design of Facility Layout

Principles which drive design of the facility layout need to take into the consideration objective of facility layout, factors influencing facility layout and constraints of facility layout. These principles are as follows:

- **Flexibility:** Facility layout should provide flexibility for expansion or modification.
- **Space Utilization:** Optimum space utilization reduces the time in material and people movement and promotes safety.
- **Capital:** Capital investment should be minimal when finalizing different models of facility layout.

Design Layout Techniques

There are three techniques of design layout, and they are as follows:

1. **Two or Three Dimensional Templates:** This technique utilizes development of a scaled-down model based on approved drawings.
2. **Sequence Analysis:** This technique utilizes computer technology in designing the facility layout by sequencing out all activities and then arranging them in circular or in a straight line.
3. **Line Balancing:** This kind of technique is used for assembly line.

Types of Facility Layout

There are six types of facility layout, and they are as follows:

- Line Layout
- Functional Layout

- Fixed Position Layout
- Cellular Technology Layout
- Combined Layout, and
- Computerized Relative Allocation of Facility Technique

(note detail refer from books all above sub heading)

PLANT LAYOUT: CONCEPT, OBJECTIVES, PRINCIPLES AND TYPES

CONCEPT OF PLANT LAYOUT:

The concept of plant layout may be described as follows:

Plant layout is a plan for effective utilisation of facilities for the manufacture of products; involving a most efficient and economical arrangement of machines, materials, personnel, storage space and all supporting services, within available floor space.

More defines plant layout as follows:

"Plant layout is a plan of optimum arrangement of facilities including personnel, equipment's, storage space, material handling equipment and all other supporting services along with the decision of best structure to contain all these facilities."

Certain useful observations on the concept of plant layout are as follows:

(i) Plant layout is very complex in nature; because it involves concepts relating to such fields as engineering, architecture, economics and business management.

(ii) Most of managers now realize that after the site for plant location is selected; it is better to develop the layout and build the building around it – rather than to construct the building first and then try to fit the layout into it.

OBJECTIVES/ADVANTAGES OF PLANT LAYOUT:

Following are the objectives/advantages of plant layout:

(i) Streamline flow of materials through the plant

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(ii) Minimise material handling

(iii) Facilitate manufacturing progress by maintaining balance in the processes

(iv) Maintain flexibility of arrangements and of operation

(v) Maintaining high turnover of in-process inventory

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(vi) Effective utilisation of men, equipment and space

(vii) Increase employee morale

(viii) Minimise interference (i.e. interruption) from machines

(ix) Reduce hazards affecting employees

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(x) Hold down investment (i.e. keep investment at a lower level) in equipment.

PRINCIPLES OF PLANT LAYOUT:

While designing the plant layout, the following principles must be kept in view:

(i) Principle of Minimum Movement:

Materials and labour should be moved over minimum distances; saving cost and time of transportation and material handling.

(ii) Principle of Space Utilization:

All available cubic space should be effectively utilized – both horizontally and vertically.

(iii) Principle of Flexibility:

Layout should be flexible enough to be adaptable to changes required by expansion or technological development.

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(iv) Principle of Interdependence:

Interdependent operations and processes should be located in close proximity to each other; to minimize product travel.

(v) Principle of Overall Integration:

All the plant facilities and services should be fully integrated into a single operating unit; to minimize cost of production.

(vi) Principle of Safety:

There should be in-built provision in the design of layout, to provide for comfort and safety of workers.

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(vii) Principle of Smooth Flow:

The layout should be so designed as to reduce work bottlenecks and facilitate uninterrupted flow of work throughout the plant.

(viii) Principle of Economy:

The layout should aim at effecting economy in terms of investment in fixed assets.

(ix) Principle of Supervision:

A good layout should facilitate effective supervision over workers.

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(x) Principle of Satisfaction:

A good layout should boost up employee morale, by providing them with maximum work satisfaction.

Principles of plant layout – at a glance

1. Minimum movement
2. Space utilisation
3. Flexibility
4. Interdependence
5. Overall integration
6. Safety
7. Smooth flow
8. Economy
9. Supervision
10. Satisfaction

TYPES OF PLANT LAYOUT:

Two basic plans of the arrangement of manufacturing facilities are – product layout and process layout. The only other alternative is a combination of product and process layouts, in the same plant.

Following is an account of the various types of plant layout:

(a) Product Layout (or Line Layout):

In this type of layout, all the machines are arranged in the sequence, as required to produce a specific product. It is called line layout because machines are arrange in a straight line. The raw materials are fed at one end and taken out as finished product to the other end.

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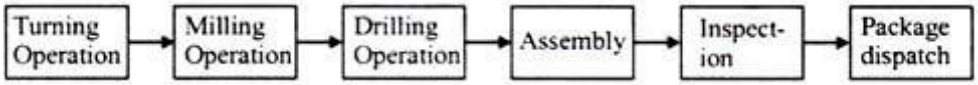
Special purpose machines are used which perform the required jobs (i.e. functions) quickly and reliably.

Product layout is depicted below:



Advantages:

1. Reduced material handling cost due to mechanized handling systems and straight flow
2. Perfect line balancing which eliminates bottlenecks and idle capacity.

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3. Short manufacturing cycle due to uninterrupted flow of materials
4. Simplified production planning and control; and simple and effective inspection of work.
5. Small amount of work-in-progress inventory
6. Lesser wage cost, as unskilled workers can learn and manage production.

Disadvantages:

1. Lack of flexibility of operations, as layout cannot be adapted to the manufacture of any other type of product.

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2. Large capital investment, because of special purpose machines.
3. Dependence of whole activity on each part; any breakdown of one machine in the sequence may result in stoppage of production.
4. Same machines duplicated for manufacture of different products; leading to high overall operational costs.
5. Delicate special purpose machines require costly maintenance / repairs.

Suitability of product layout:

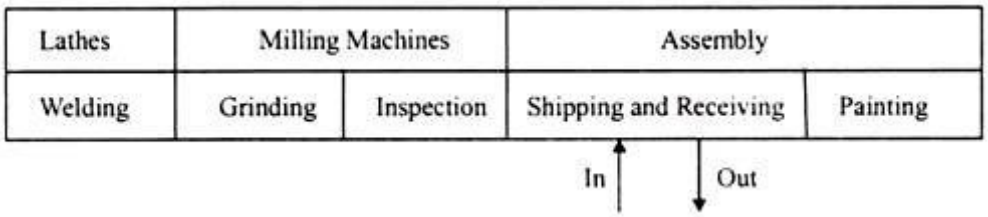
Product layout is suitable in the following cases:

1. Where one or few standardized products are manufactured.
2. Where a large volume of production of each item has to travel the production process, over a considerable period of time.
3. Where time and motion studies can be done to determine the rate of work.
4. Where a possibility of a good balance of labour and equipment exists.
5. Where minimum of inspection is required, during sequence of operations.
6. Where materials and products permit bulk or continuous handling by mechanical parts.

7. Where minimum of set-ups are required.

(b) Process Layout (or Functional Layout):
In this type of layout, all machines performing similar type of operations are grouped at one location i.e. all lathes, milling machines etc. are grouped in the shop and they will be clustered in like groups.

A typical process layout is depicted below:



Advantages:
1. Greater flexibility with regard to work distribution to machinery and personnel. Adapted to frequent changes in sequence of operations.
2. Lower investment due to general purpose machines; which usually are less costly than special purpose machines.
3. Higher utilisation of production facilities; which can be adapted to a variety of products.
4. Variety of jobs makes the work challenging and interesting.
5. Breakdown of one machine does not result in complete stoppage of work.

Disadvantages:
1. Backtracking and long movements occur in handling of materials. As such, material handling costs are higher.
2. Mechanisation of material handling is not possible.
3. Production planning and control is difficult
4. More space requirement; as work-in-progress inventory is high-requiring greater storage space.
5. As the work has to pass through different departments; it is quite difficult to trace the responsibility for the finished product.

Suitability of process layout:
Process layout is suitable in the following cases, where:
1. Non-standardised products are manufactured; as the emphasis is on special orders.
2. It is difficult to achieve good labour and equipment balance.
3. Production is not carried on a large scale.
4. It is difficult to undertake adequate time and motion studies.
5. It is frequently necessary to use the same machine or work station for two or more difficult operations.
6. During the sequence of operations, many inspections are required.
7. Process may have to be brought to work, instead of **"vice-versa"**; because materials or products are too large or heavy to permit bulk or continuous handling by mechanical means.

(c) Combination Layout:
In practice, plants are rarely laid out either in product or process layout form. Generally a combination of the two basic layouts is employed; to derive the advantages of both systems of layout. For example, refrigerator manufacturing uses a combination layout.
Process layout is used to produce various operations like stamping, welding, heat treatment being carried out in different work centres as per requirement. The final assembly of the product is done in a product type layout.

(d) Fixed Position Layout:
It is also called stationary layout. In this type of layout men, materials and machines are brought to a product that remains in one place owing to its size. Ship-building, air-craft manufacturing, wagon building, heavy construction of dams, bridges, buildings etc. are typical examples of such layout.

TOOLS AND TECHNIQUES USED FOR INDUSTRIAL LAYOUT PLANNING

The six tools and techniques used for layout planning/plant layout are as follows: 1. Operation process charts 2. Flow process charts 3. Process flow diagram 4. Machine date cards 5. Templates 6. Scale models.

1. Operation Process Chart:
The manufacturing process is divided into separate operations with the help of the operation process chart. It shows the points at which materials are introduced into the process and the sequence of various operations and inspections other than material handling.
The operation process chart is meant for new plant which is to be laid out. This chart represents the basic activities required for producing a product. Since it presents the overall visualization of the process, basis for studying possibilities for the improvement of operations by elimination, combination, rearrangement or simplification is available.

2. Flow Process Chart:
This chart is a graphic representation of all the production activities occurring on the shop floor. It may be considered as an elaboration of the operation process chart which includes transportation, storage and delay. The data required for preparing the flow process chart are collected by tracing the actual flow of work occurring in the distance moved and the time required for the operation.
The flow process chart provides the complete information for the analysis and improvement of the unit/plant operations as a whole. On the basis of this analysis, operations may be combined, rearranged or eliminated.
Work station, storage space and inspection may be reallocated to minimize distances moved and labour time. An improved flow process chart provides a basis for revising an existing plant layout. The charts are also utilized to check and verify the efficiency of a proposed new layout.

3. Process Flow Diagrams:
This diagram is used to supplement the flow process chart. It is the diagram of building plan representing graphically the relative position of productive machinery storage space, gangways etc. and path followed by men or materials. All routes followed by different items are shown by joining symbols with straight lines.

It is possible to trace out the undesirable characteristics of the layout which are responsible for increased transportation and delay by studying the process flow diagrams and flow process chart. It also shows nature of back tracking of present layout which there by helps in improving the layout.

4. Machine Data Cards:

These cards give complete specification of each machine to be installed showing its capacity, space and other requirements, foundations methods of operation, maintenance and handling devices of machines etc.

5. Templates:

After studying the flow process chart, process flow diagram and machine data cards, a floor plan is prepared by fixing the area occupied by each item (machine/equipment, benches, racks, material handling equipment etc.) to be erected in the shops.

Now from the thick sheets of cardboard, plywood or plastic on the same scale pieces of sheet are cut (known as templates) to represent various items which are to be housed in the plants and are placed on the floor plans at suitable locations.

These templates are arranged in such a way so as to provide the best layout. This procedure makes the layout visual before actually drawn and is carefully examined. The changes, if any, are in corporate before making the actual layout drawing.

6. Scale Models:

It is an improvement over the template technique. In this tools, instead of templates, three dimensional scale model is utilized. These models may be of wood plastic or metals. When these are used on a layout, series of additional information about the height and of the projected components of the machines are obtained. This tool is useful for complete layout which initially requires huge investment.

UNIT IV

DEMAND FORECASTING

MEANING OF DEMAND FORECASTING

Demand forecasting is a process of predicting future demand for company's product over a definite period of time. It is simply all about making estimations about the behavior of customers using historical data and various other information. Demand forecasting gives business an idea about the quantity of goods or services which are likely to be purchased by people in foreseeable future. It is very important element for organization as it provides them with valuable information regarding their potential in current market and other markets. Management of company are able to take informed decisions related to pricing, market potential and business growth strategies.

Every business operates in world of uncertainty, tough competition and higher risk. A business come across different risks which are either internal or external to its operations such as attrition, technology, inflation, recession, variations in laws etc. There is a need to take right decisions and proper planning by every business about future events in such competitive market conditions. Demand forecasting assist them in decisions related to sales, production, inventory management and whether to enter a new market or not by providing idea on future possibilities.

Types of Demand forecasting

arious types of demand forecasting are well-explained in points given below: –

1. **Passive demand forecasting:** Passive demand forecasting is the simplest type of demand forecasting used for stable business with conservative growth plans. In this model, a simple extrapolation of past data is done with minimal assumptions for predicting the future. It does not require to study the economic trends or use any statistical methods. This type of forecasting is more probably used in case of local and small businesses.
2. **Active demand forecasting:** This type of forecasting is carried out for business having an aggressive plan of growth. A active forecasting model studies your marketing research, market campaigns and expansion plans. It takes into consideration the external factors such as economic outlook, economic environment, competitor activities and growth projection for market sector. Active forecasting model is more favorable for starts-up business having lack of historical data and need to make assumptions on external data basis.
3. **Short-term demand forecasting:** The short-term demand forecasting model is used to make predictions for shorter time period of 3 to 12 months. It facilitates in managing the just-in time supply chain thereby responding quickly to varying customer demand. This model of demand forecasting takes into consideration the seasonal pattern of demand as well as effect of tactical decisions on customer demand.
4. **Long-term demand forecasting:** Long-term demand model is meant for making projections of more than 12 months to 48 months. It is treated as a roadmap which enables business in shaping its growth trajectory. The long-term demand forecasting enables in sales and marketing planning, financial planning, planning of business strategy, capital planning, capital expenditure etc.
5. **External macro forecasting:** This forecasting model deals with trends in broader market which are dependent upon the macroeconomic environment. External macro forecasting studies how these trends influence your goals and provide direction for reaching to those

goals. It evaluates strategic objectives of organization such as expansion of product portfolio, technological disruptions, risk mitigation strategies and entering new segments of customer.

6. **Internal business forecasting:** It is concerned with internal operations of business which determines its capability for growth. The internal operations are product category, manufacturing group, financial division and sales division. Internal business forecasting helps in uncovering limitations which may obstruct your growth and highlight areas of opportunities available to business. It is an efficient tool in making realistic projections.

Steps in Demand Forecasting

Following steps are involved in a process of demand forecasting: –

1. **Identifying objectives:** In first step, the purpose or objectives for which the demand forecasting is to carried out should be clearly specified. The objective need to be well-defined in terms of short or long-term demand, firm's market share, the whole market or only a segment of it for firm's product etc. Proper specification of objective will provide a right direction to whole research.
2. **Determining time perspective:** The demand may be forecasted either for short period or long period depending upon the objectives of firm. In case of short-term demand forecasting that is for next 2 to 3 years, many determinants of demand do not change significantly and can be taken as constant. Whereas the demand determinants change significantly in case of long run forecasting. It is required to clearly specify the time perspective of forecasting to be done.
3. **Choosing the forecasting method:** Now a forecasting method is chosen once the objectives and time perspective is specified. There are different methods of demand forecasting which are categorized into 2 types: survey methods and statistical methods. In survey method, opinions polls and consumer survey methods are used. Whereas econometric, trend projection and barometric methods are used in statistical methods. Both of these method type differ from one another on the basis of type of data required, forecasting purpose, time frame of forecasting and availability of data. Only that method should be chosen which best suits the requirement.
4. **Collection of data and data adjustment:** Now the data required for doing forecasting is selected which can be primary or secondary data or even both. The first-hand data which is not collected before is termed as primary data. Whereas the data already collected in past by someone is known as secondary data. Sometimes the data is even adjusted or manipulated when the required set of data is not available. This is done to build consistency of data with the data required.
5. **Interpretation of results:** Now finally the demand is forecasted for predefined time period. It is done at last stage once the forecasting method is finalized and required set of data is collected. Usually, the equations are used for showing the estimates while results are interpreted in an easy and usable form.

Demand forecasting is carried out in a right manner and the required objectives are attained if abovementioned steps are followed systematically.

Objectives of Demand Forecasting

The objectives of demand forecasting are summarized in points below: –

1. **Formulation of production policy:** Demand forecasting helps in formulation of suitable production policy by estimating demand for future. A business can accordingly procure

and maintain sufficient amount of raw materials to ensure interrupted production for future demands as per the forecast. This will enable to cover the gap in between the demand and supply of product.

2. **Price policy formulation:** It is one of the most important objective of demand forecasting. This enables business in formulating an effective price mechanism so that level of prices does not fluctuates much during the inflation or depression phase.
3. **Control of sales:** Demand forecasting enables in controlling the sales by doing sales forecasting of product or services on a regional basis. This way the sales target is set for each area and then performance of sales is evaluated on this basis.
4. **Finance arrangements:** It help organization in maintaining proper liquidity by making estimations on funds requirements. By forecasting the sales and liquidity requirements of business, cost of obtaining finance is minimized.
5. **Regulates supply of materials:** Demand forecasting regulate the supply of raw materials by determining the level of production within the business. This way a continuous supply of raw materials can be planned leading to better inventory management.
6. **Regulates labor supply:** Labor expenses is important component in cost of production. Proper sales forecasts enable business in acquiring appropriate and skilled labor.
7. **Deciding production capacity:** Demand forecasting assist business in properly deciding its production capacity. A firm can easily determine the size of production plant needed for fulfilling the production requirements with the help of sale forecast.
8. **Capital restructuring:** Demand forecasting for long term can enable business in financial planning for long-term. It can raise require funds at reasonable rates and suitable terms form distinct sources including internal as well as external source.

Importance of Demand Forecasting

The importance of demand forecasting is as given below: –

1. **Producing desired output:** Demand forecasting enables business in producing the desired output by pre-determining the required production level. Organization can easily arrange for needed factors of production beforehand so that there is no hindrance to carry out the production activities.
2. **Estimating probable demand:** It assists in doing right planning of business activities by accessing the probable demand of products in a given time period. Demand forecasting avoid instances of merely making assumptions for demand by business enterprise.
3. **Better control:** Demand forecasting enables in developing proper understanding of cost budgets and profit analysis. Having a good understanding on all this facilitate to exercise better control on business activities.
4. **Forecasting sales figures:** Sales forecasting involves predicting the sale figures of organization for a given period of time. Demand forecasting make estimations about sales figure using historical data and studying current market trends.
5. **Ensure stability:** Demand forecasting facilitate the business organization in stabilizing their operations. It helps them in formulating suitable policies in order to meet cyclical as well as the seasonal fluctuations within the economy.
6. **Controlling inventory:** Demand forecasting estimate the future demand for business products and services. This way organization are able to do pre-planning for acquiring raw materials, spare parts, semi-finished goods etc.

Methods of qualitative

Qualitative researchers use their own eyes, ears, and intelligence to collect in-depth perceptions and descriptions of targeted populations, places, and events.

Their findings are collected through a variety of methods, and often a researcher will use at least two or several of the following while conducting a qualitative study:

- Direct observation: With direct observation, a researcher studies people as they go about their daily lives without participating or interfering. This type of research is often unknown to those under study, and as such, must be conducted in public settings where people do not have a reasonable expectation of privacy. For example, a researcher might observe the ways in which strangers interact in public as they gather to watch a street performer.
- Open-ended surveys: While many surveys are designed to generate quantitative data, many are also designed with open-ended questions that allow for the generation and analysis of qualitative data. For example, a survey might be used to investigate not just which political candidates voters chose, but why they chose them, in their own words.
- Focus group: In a focus group, a researcher engages a small group of participants in a conversation designed to generate data relevant to the research question. Focus groups can contain anywhere from 5 to 15 participants. Social scientists often use them in studies that examine an event or trend that occurs within a specific community. They are common in market research, too.
- In-depth interviews: Researchers conduct in-depth interviews by speaking with participants in a one-on-one setting. Sometimes a researcher approaches the interview with a predetermined list of questions or topics for discussion but allows the conversation to evolve based on how the participant responds. Other times, the researcher has identified certain topics of interest but does not have a formal guide for the conversation, but allows the participant to guide it.
- Oral history: The oral history method is used to create a historical account of an event, group, or community, and typically involves a series of in-depth interviews conducted with one or multiple participants over an extended period.
- Participant observation: This method is similar to observation, however with this one, the researcher also participates in the action or events to not only observe others but to gain the first-hand experience in the setting.
- Ethnographic observation: Ethnographic observation is the most intensive and in-depth observational method. Originating in anthropology, with this method, a researcher fully immerses themselves into the research setting and lives among the participants as one of them for anywhere from months to years. By doing this, the researcher attempts to experience day-to-day existence from the viewpoints of those studied to develop in-depth and long-term accounts of the community, events, or trends under observation.
- Content analysis: This method is used by sociologists to analyze social life by interpreting words and images from documents, film, art, music, and other cultural products and media. The researchers look at how the words and images are used, and the context in which they are used to draw inferences about the underlying culture. Content analysis of digital material, especially that generated by social media users, has become a popular technique within the social sciences.

While much of the data generated by qualitative research is coded and analyzed using just the researcher's eyes and brain, the use of computer software to do these processes is increasingly popular within the social sciences.
Such software analysis works well when the data is too large for humans to handle, though the lack of a human interpreter is a common criticism of the use of computer software.

Pros and Cons

Qualitative research has both benefits and drawbacks.
On the plus side, it creates an in-depth understanding of the attitudes, behaviors, interactions, events, and social processes that comprise everyday life. In doing so, it helps social scientists understand how everyday life is influenced by society-wide things like social structure, social order, and all kinds of social forces.
This set of methods also has the benefit of being flexible and easily adaptable to changes in the research environment and can be conducted with minimal cost in many cases.
Among the downsides of qualitative research is that its scope is fairly limited so its findings are not always widely able to be generalized.
Researchers also have to use caution with these methods to ensure that they do not influence the data in ways that significantly change it and that they do not bring undue personal bias to their interpretation of the findings.
Fortunately, qualitative researchers receive rigorous training designed to eliminate or reduce these types of research bias.

Definition of Qualitative Research

Qualitative research is one which provides insights and understanding of the problem setting. It is an unstructured, exploratory research method that studies highly complex phenomena that are impossible to elucidate with the quantitative research. Although, it generates ideas or hypothesis for later quantitative research.
Qualitative research is used to gain an in-depth understanding of human behaviour, experience, attitudes, intentions, and motivations, on the basis of observation and interpretation, to find out the way people think and feel. It is a form of research in which the researcher gives more weight to the views of the participants. Case study, grounded theory, ethnography, historical and phenomenology are the types of qualitative research.

Definition of Quantitative Research

Quantitative research is a form of research that relies on the methods of natural sciences, which produces numerical data and hard facts. It aims at establishing cause and effect relationship between two variables by using mathematical, computational and statistical methods. The research is also known as empirical research as it can be accurately and precisely measured.
The data collected by the researcher can be divided into categories or put into rank, or it can be measured in terms of units of measurement. Graphs and tables of raw data can be constructed with the help quantitative research, making it easier for the researcher to analyse the results.

COMPARISON CHART

Basis for Comparison	**Qualitative Research**	**Quantitative Research**
Meaning	Qualitative research is a method of inquiry that develops understanding	Quantitative research is a research method that is used to generate numerical

Basis for Comparison	Qualitative Research	Quantitative Research
	on human and social sciences, to find the way people think and feel.	data and hard facts, by employing statistical, logical and mathematical technique.
Nature	Holistic	Particularistic
Approach	Subjective	Objective
Research type	Exploratory	Conclusive
Reasoning	Inductive	Deductive
Sampling	Purposive	Random
Data	Verbal	Measurable
Inquiry	Process-oriented	Result-oriented
Hypothesis	Generated	Tested
Elements of analysis	Words, pictures and objects	Numerical data
Objective	To explore and discover ideas used in the ongoing processes.	To examine cause and effect relationship between variables.
Methods	Non-structured techniques like In-depth interviews, group discussions etc.	Structured techniques such as surveys, questionnaires and observations.
Result	Develops initial understanding	Recommends final course of action

Key Differences between Qualitative and Quantitative

The differences between qualitative and quantitative research are provided can be drawn clearly on the following grounds:

1. Qualitative research is a method of inquiry that develops understanding on human and social sciences, to find the way people think and feel. A scientific and empirical research method that is used to generate numerical data, by employing statistical, logical and mathematical technique is called quantitative research.
2. Qualitative research is holistic in nature while quantitative research is particularistic.
3. The qualitative research follows a subjective approach as the researcher is intimately involved, whereas the approach of quantitative research is objective, as the researcher is uninvolved and attempts to precise the observations and analysis on the topic to answer the inquiry.
4. Qualitative research is exploratory. As opposed to quantitative research which is conclusive.
5. The reasoning used to synthesise data in qualitative research is inductive whereas in the case of quantitative research the reasoning is deductive.

6. Qualitative research is based on purposive sampling, where a small sample size is selected with a view to get a thorough understanding of the target concept. On the other hand, quantitative research relies on random sampling; wherein a large representative sample is chosen in order to extrapolate the results to the whole population.
7. Verbal data are collected in qualitative research. Conversely, in quantitative research measurable data is gathered.
8. Inquiry in qualitative research is a process-oriented, which is not in the case of quantitative research.
9. Elements used in the analysis of qualitative research are words, pictures, and objects while that of quantitative research is numerical data.
10. Qualitative Research is conducted with the aim of exploring and discovering ideas used in the ongoing processes. As opposed to quantitative research the purpose is to examine cause and effect relationship between variables.
11. Lastly, the methods used in qualitative research are in-depth interviews, focus groups, etc. In contrast, the methods of conducting quantitative research are structured interviews and observations.
12. Qualitative Research develops the initial understanding whereas quantitative research recommends a final course of action.

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What is a strategic plan?

A *strategic plan* outlines your mission, vision, and high-level goals for the next three to five years. It also takes into account how you'll measure those goals, and the major projects you'll take on to meet them.

What is an operational plan?

An *operational plan* (also known as a *work plan*) is a highly detailed outline of what your department will focus on for the near future—usually the upcoming year. The plan will answer questions - who, what, when, and how much - regarding daily or weekly tasks.

Simply put, your strategic plan shares your vision for the future, while your operational plan lays out how you'll get there on a daily to weekly basis.

Both concepts describe your company's plans for the future, but in different contexts.

Strategic & Operational Planning Examples

Take Meta, for example (formerly Facebook). The company recently announced that an important part of its strategy will be building a new computing platform called a metaverse—a shared virtual world environment. This is a long-term goal that leader Mark Zuckerberg says is "critical to [the company's] mission." The creation of this new metaverse would be considered part of the company's *strategic plan.*

To accomplish that goal, Meta needs to derive an *operational plan* outlining tasks that need to be done. Numerous components are involved in creating such a platform—everything from creating standards and protocols for the virtual world to developing the necessary hardware and software to determining how to monetize the experience, and much, much more. Meta has to detail *which* specific activities its people need to do in each area and *when* they'll need to do them. This operational plan will ensure they meet certain milestones and that the company continues moving in the right direction over the long term.

A simpler strategic and operational planning example: Say you have a strategic plan modeled after the Balanced Scorecard. It names the high-level goals your organization is trying to accomplish in each of the four perspectives. It also includes aligned and linked measures and projects designed to help you achieve your objectives. Based on that strategic plan, each department in your company will then need to develop an operational plan for the projects they are responsible for to determine how the work will get done. Completing those projects will help you stay on track to accomplish your goals.

STRATEGIC PLANNING VS. OPERATIONAL PLANNING: 7 DIFFERENCES

To clarify the concepts of strategic vs. operational—and help you put them into practice—take a look at seven of the most significant differences between the two ideas:

1. Time Period

Your strategic plan outlines long-term goals for the next three to five years. What you'll be doing to achieve those goals in the shorter term (typically the next fiscal year) is outlined in your operational plan.

2. Modification

Your strategic plan should be fairly weatherproof, but that doesn't mean it won't occasionally require modifications. Evaluate your strategic plan yearly to see if it still makes sense in case of dramatic changes happening inside or outside the organization, for example, or unexpected performance results. It's also possible that new opportunities (or threats) may have arisen in the past year that require consideration.

In contrast, you should reevaluate your operational plan monthly. While your strategy may be able to handle the unexpected, the path to reaching your long-term goals is somewhat fluid.

3. Goal

The goal of your strategic plan is to outline the company's long-term vision and how all departments should work together to achieve it. Because goals are company-focused, strategic plans are more broad in scope than operational plans.

The goal of an operational plan applies to specific departments, not the company as a whole. There can be overlap between departments, but that's the exception rather than the rule. Large departments may require multiple operational plans. Because of its narrower focus, an operational plan is inherently more detailed than a strategic plan—it outlines how you're going to get it all done!

4. Plan Generation

Your organization's high-level leadership team—the executive team or city council, for instance—is responsible for creating the strategic plan. Once it's created, the strategic plan will be pushed forward by cross-functional teams who work together to ensure the strategy is successful.

5. Budget

The budget for your strategic plan comes from your strategic budget, not your operational budget. Your organization may implement a Strat-Ex budget that aligns part of your budget directly to your strategic projects or initiatives. This is a different approach than putting a budget against each of your divisions or departments.

The budget for your operational plan comes from your department's annual budget. If your annual department budget needs to be cut, consider which elements don't align to your strategic plan and cut those first. For example, if your strategic plan defines a marketing goal of establishing a strong online presence, your trade show budget should receive budget cuts before blog writing does.

6. Reporting

When you report on your strategic plan (typically both annually and quarterly), your strategic planning committee or executive team will want to look at how your company is performing on its chosen measures. Depending on the meeting, these discussions should remain fairly high-level so you don't get bogged down on details.

Your operational reports, on the other hand, outline hundreds of projects or tasks people in the department are working on. Monthly operational reporting meetings give the leadership—and the rest of the department—an indication of each project's status.

Unlike your strategic report, updates on operational projects can be anecdotal or qualitative (as it's often difficult to quantify actions that aren't tied to measures). Some organizations have a running text commentary either in an Excel field or a Word document. This commentary is updated weekly or monthly, even if there are no direct measures for that part of the operational plan.

7. Focus

Your strategic plan revolves around how your organization can be *different*. What sets you apart from other organizations is your mission and vision; the goals you set tie into those concepts. Thus, a strategic plan distinguishes your organization's direction as being different from that of other companies.

In contrast, your operational plan revolves around being *better* operationally. If you can implement and execute your strategy efficiently and effectively, your chances of successfully reaching your business objectives increase significantly.

RESOURCE PLANNING DEFINITION

Resource Planning is a process of **identifying**, **forecasting**, and **allocating** various types of business resources to the projects at the right time and cost. It also ensures the efficient and effective utilization of resources across the enterprise. These business resources can be human resources, equipment, assets, facilities, and more.

RESOURCE PLANNING SYSTEMS:

Resource Planning Systems are those that can be used for planning and maintaining the resources that are required for manufacturing process. The main objective is to ensure that the materials are available and in accordance to plan the production systems. Planning of resources is one of the essential requirements for any industry. Resource planning systems can be classified as follows,

- Material Requirements Planning (MRP)
- Capacity Requirements Planning (CRP)

• Enterprise Resource Planning*...show more content...*
It contains the bill of materials which specifies the list of materials needed for production and various process in it. The brief description of each material used is given in the list.

ITEM MASTER FILE: Item master file is a database of information on every item produced, ordered or inventoried. It include data such as lot sizes, safety stock, lead time and many other things. The various techniques used in this includes, cycle counting, netting, lot sizing, time phasing, explosion and expedite. Thus by maintaining these process better outputs will be obtained and also planning makes efficient usage of resources.

CAPACITY REQUIREMENTS PLANNING (CRP): Capacity Requirements Planning is a computerized system that creates a load profile that identifies underloads and overloads. The process of determining short-range capacity requirements from MRP outputs.

There are three major inputs to CRP,
• Planned order release
• Routine file
• Open order file

CAPACITY:
The capacity is the maximum capability to produce. It can be measured in terms of units of outputs, dollars of output, hours of work.
Effective daily capacity = (No. of machines or workers) * (hours per shift) * (No. of shifts) * (utilization) * (efficiency)
Load percent = (Load/capacity)*100.

WHAT IS INVENTORY MANAGEMENT?
Inventory management helps companies identify which and how much stock to order at what time. It tracks inventory from purchase to the sale of goods. The practice identifies and responds to trends to ensure there's always enough stock to fulfill customer orders and proper warning of a shortage.
Once sold, inventory becomes revenue. Before it sells, inventory (although reported as an asset on the balance sheet) ties up cash. Therefore, too much stock costs money and reduces cash flow. One measurement of good inventory management is inventory turnover. An accounting measurement, inventory turnover reflects how often stock is sold in a period. A business does not want more stock than sales. Poor inventory turnover can lead to deadstock, or unsold stock.

What is inventory?

Inventory is the goods that your company handles with the intention of selling. It might be raw materials that you buy and turn into something entirely new, or it might be a bulk product that you break down into its constituent parts and sell separately. It could even be something completely intangible: software, for instance.

Why Is Inventory Management Important?

Inventory management is vital to a company's health because it helps make sure there is rarely too much or too little stock on hand, limiting the risk of stockouts and inaccurate records.

Public companies must track inventory as a requirement for compliance with Securities and Exchange Commission (SEC) rules and the Sarbanes-Oxley (SOX) Act. Companies must document their management processes to prove compliance.

Benefits of Inventory Management

The two main benefits of inventory management are that it ensures you're able to fulfill incoming or open orders and raises profits. Inventory management also:

- **Saves Money:**
  Understanding stock trends means you see how much of and where you have something in stock so you're better able to use the stock you have. This also allows you to keep less stock at each location (store, warehouse), as you're able to pull from anywhere to fulfill orders — all of this decreases costs tied up in inventory and decreases the amount of stock that goes unsold before it's obsolete.
- **Improves Cash Flow:**
  With proper inventory management, you spend money on inventory that sells, so cash is always moving through the business.
- **Satisfies Customers:**
  One element of developing loyal customers is ensuring they receive the items they want without waiting.

Inventory Management Challenges

The primary challenges of inventory management are having too much inventory and not being able to sell it, not having enough inventory to fulfill orders, and not understanding what items you have in inventory and where they're located. Other obstacles include:

- **Getting Accurate Stock Details:**
  If you don't have accurate stock details,there's no way to know when to refill stock or which stock moves well.
- **Poor Processes:**
  Outdated or manual processes can make work error-prone and slow down operations.
- **Changing Customer Demand:**
  Customer tastes and needs change constantly. If your system can't track trends, how will you know when their preferences change and why?
- **Using Warehouse Space Well:**
  Staff wastes time if like products are hard to locate. Mastering inventory management can help eliminate this challenge.

Learn more about the challenges and benefits of inventory management.

What Is Inventory?

Inventory is the raw materials, components and finished goods a company sells or uses in production. Accounting considers inventory an asset. Accountants use the information about stock levels to record the correct valuations on the balance sheet.

Learn more about inventory in the article "What Is Inventory?".

Inventory vs. Stock

Inventory is often called stock in retail businesses: Managers frequently use the term "stock on hand" to refer to products like apparel and housewares. Across industries, "inventory" more broadly refers to stored sales goods and raw materials and parts used in production.

Some people also say that the word "stock" is used more commonly in the U.K. to refer to inventory. While there is a difference between the two, the terms inventory and stock are often interchangeable.

What Are the Different Types of Inventory?

There are 12 different types of inventory: raw materials, work-in-progress (WIP), finished goods, decoupling inventory, safety stock, packing materials, cycle inventory, service inventory, transit, theoretical, excess and maintenance, repair and operations (MRO). Some people do not recognize MRO as a type of inventory.

Learn more about the 12 different types of inventory.

INVENTORY MANAGEMENT PROCESS

If you produce on demand, the inventory management process starts when a company receives a customer order and continues until the order ships. Otherwise, the process begins when you forecast your demand and then place POs for the required raw materials or components. Other parts of the process include analyzing sales trends and organizing the storage of products in warehouses.

How Inventory Management Works

The goal of inventory management is to understand stock levels and stock's location in warehouses. Inventory management software tracks the flow of products from supplier through the production process to the customer. In the warehouse, inventory management tracks stock receipt, picking, packing and shipping.

INVENTORY MANAGEMENT TECHNIQUES AND TERMS

Some inventory management techniques use formulas and analysis to plan stock. Others rely on procedures. All methods aim to improve accuracy. The techniques a company uses depend on its needs and stock.

Find out which technique works best for your business by reading the guide to inventory management techniques. Here's a summary of them:

- **ABC Analysis:**
  This method works by identifying the most and least popular types of stock.

- **Batch Tracking:**
  This method groups similar items to track expiration dates and trace defective items.
- **Bulk Shipments:**
  This method considers unpacked materials that suppliers load directly into ships or trucks. It involves buying, storing and shipping inventory in bulk.
- **Consignment:**
  When practicing consignment inventory management, your business won't pay its supplier until a given product is sold. That supplier also retains ownership of the inventory until your company sells it.
- **Cross-Docking:**
  Using this method, you'll unload items directly from a supplier truck to the delivery truck. Warehousing is essentially eliminated.
- **Demand Forecasting:**
  This form of predictive analytics helps predict customer demand.
- **Dropshipping:**
  In the practice of dropshipping, the supplier ships items directly from its warehouse to the customer.
- **Economic Order Quantity (EOQ):**
  This formula shows exactly how much inventory a company should order to reduce holding and other costs.
- **FIFO and LIFO:**
  First in, first out (FIFO) means you move the oldest stock first. Last in, first out (LIFO) considers that prices always rise, so the most recently-purchased inventory is the most expensive and thus sold first.
- **Just-In-Time Inventory (JIT):**
  Companies use this method in an effort to maintain the lowest stock levels possible before a refill.
- **Lean Manufacturing:**
  This methodology focuses on removing waste or any item that does not provide value to the customer from the manufacturing system.
- **Materials Requirements Planning (MRP):**
  This system handles planning, scheduling and inventory control for manufacturing.
- **Minimum Order Quantity:**
  A company that relies on minimum order quantity will order minimum amounts of inventory from wholesalers in each order to keep costs low.
- **Reorder Point Formula:**
  Businesses use this formula to find the minimum amount of stock they should have before reordering, then manage their inventory accordingly.
- **Perpetual Inventory Management:**
  This technique entails recording stock sales and usage in real-time. Read "The Definitive Guide to Perpetual Inventory" to learn more about this practice.
- **Safety Stock:**
  An inventory management ethos that prioritizes safety stock will ensure there's always extra stock set aside in case the company can't replenish those items.
- **Six Sigma:**
  This is a data-based method for removing waste from businesses as it relates to inventory.

- **Lean Six Sigma:**
  This method combines lean management and Six Sigma practices to remove waste and raise efficiency.

Inventory vs. Cycle Counting

"Taking inventory" is the process of physically counting all stock, once a year in most cases. Cycle counting is the practice of counting a selected set of stock more often. Cycle counting serves as an important means of checks and balances to ensure the amount of inventory represented in the inventory management system is what you have on the shelf.

A cycle counting best practice is to count specific SKUs regularly and integrate it into the daily tasks of warehouse staff. Companies may determine different standards for different types of inventory, such as performing a cycle count of top-moving SKUs or higher-value items. Learn more about the benefits of cycle counting.

Your Complete Guide to Inventory Forecasting

Effective inventory forecasting can mean the difference between profitability and piles of unsold goods that eat up your available cash. The bottom-line impact of inventory forecasting is clear: less money is tied up in inventory, stock is maintained at a realistic threshold and ordering becomes much more precise.

Demand Planning and Inventory Management

Demand planning is an important part of successful inventory management. It is the process of determining how much of each item you anticipate selling, and when. Once demand is determined, inventory management follows the flow of goods from the supplier through production and ultimately fulfilling customer orders.

Find out more about how demand planning and inventory management work together in the "Essential Guide to Inventory Planning."

Inventory Management Formulas

Understanding inventory management formulas is crucial to optimizing stock levels. Multiple inventory and accounting professionals have vetted formulas to make inventory calculations easier.

Inventory Management KPIs

Effective inventory management plays an important role throughout the supply chain. There are many key performance indicators for measuring inventory management success throughout the different organizations in the business. Understand which calculations return the most insight into your business processes is important. To learn more, see inventory management KPIs.

How Is Inventory Management Different From Other Processes?

People sometimes confuse inventory management with related practices. Inventory management controls all stock within a company. Supply chain management manages the process from supplier to delivering the product to the customer. Warehouse management is a part of inventory control and focuses on stock in a specific location.

Inventory Management vs. Inventory Control

inventory control is a part of the overall inventory management process. Inventory control manages the movement of items within the warehouse.

Learn more about how these practices work together in our article on inventory control vs. inventory management.

Inventory Management vs. Inventory Optimization

Inventory optimization is the process of using inventory in the most efficient way, and as a result minimizing the dollars spent on stock and storing those items.

You can also think about inventory optimization as seeing inventory across all locations and selling channels, being able to use any of it to fulfill customer orders—in doing so, you can hold less stock overall.

Inventory Management vs. Order Management

Inventory management is responsible for ordering and tracking stock as it arrives at the warehouse. Order management is the process of receiving and tracking customer orders. Software often combines both tasks.

Inventory management plays an important role in order management. As orders are received, inventory can be allocated to specific orders, and then the status can be changed in the inventory record to essentially put it "on hold" for that order. Furthermore, when the order management system and inventory system are integrated, the inventory system can recommend which location should fulfill the order, based on where all the items in the order are available—this eliminates multiple shipments for a single order.

Inventory Management vs. Supply Chain Management

Supply chain management is a process of managing supply relationships outside a company and the flow of stock into and through a company. Inventory management may focus on trends and orders for the company or a part of the company.

Inventory management is essential for a properly running supply chain. Inventory management follows the flow of goods to, through and out of the warehouse. The supply chain includes demand planning, procurement, production, quality, fulfillment, warehousing and customer service—all of which require inventory visibility.

Inventory Management vs. Warehouse Management

Warehouse management complements inventory management. Warehouse management organizes stock in a warehouse. Inventory management manages stock and trends for many warehouses or an entire company.

The key to streamlining your warehouse operations is a thoughtfully laid out and meticulously organized facility. When each product has a specific place in the warehouse, it prevents staff from moving about inefficiently and maximizes labor efficiency. But these processes are only as good as the inventory records that drive them.

Learn more about how warehouse management and inventory management work together.

Inventory Management vs. Logistics

Logistics is the practice of controlling processes in a warehouse and in the replenishment and delivery systems. Inventory management maintains stock levels and manages stock location.

Inventory management is a crucial part of how companies manipulate their logistics. The relationship between inventory management and logistics is interdependent. Logistics need inventory management to perform their activities. Good logistics systems improve warehouse and operational activities.

Find out more about this topic by reading "The Benefits of Integrating Your Inventory Software With Your Accounting and Back-Office Processes."

Inventory Management vs. ERP

An enterprise resource planning (ERP) system is software that manages business activities such as accounting, purchasing, compliance and supply chain operations. By contrast, inventory management is a part of a modern ERP system, providing insight into stock levels, inventory en route and the status of current inventory—this makes it visible across the organization in real time.

Inventory management helps to properly plan a company's replenishment orders. ERP systems give companies accurate inventory data, so they have the most current information for their inventory management plan. ERP systems optimize the data so inventory management is successful.

INVENTORY MANAGEMENT TECHNIQUES

Especially for larger apps with lots of moving parts, inventory management can become complex, encompassing several techniques and strategies. Let's take a look at some inventory control techniques you may choose to utilize in your own warehouse.

Economic order quantity.

Economic order quantity (EOQ) is a formula for how much inventory a company should purchase with a set of variables like total costs of production, demand rate and other factors. The formula identifies the greatest number of units in order to minimize buying, holding and other costs.

Minimum order quantity.

Minimum order quantity (MOQ) is the smallest amount of inventory a retail business will purchase in order to keep costs low. However, keep in mind that inventory items that cost more to produce typically have a smaller MOQ, as opposed to cheaper items that are easier and more cost effective to make.

ABC analysis.

This technique splits goods into three categories to identify items that have a heavy impact on overall inventory cost.

- **Category A** is your most valuable products that contribute the most to overall profit.
- **Category B** is the products that fall in between the most and least valuable.
- **Category C** is for small transactions that are vital for overall profit but don't matter much individually.

Just-in-time inventory management.

Just-in-time (JIT) inventory management is a technique in which companies receive inventory on an as-needed basis instead of ordering too much and risking dead stock (inventory that was never sold or used by customers before being removed from sale status).

Safety stock inventory.

Safety stock inventory management is extra inventory that is ordered and set aside in case the company doesn't have enough for replenishment. This helps prevent stock-outs typically caused by incorrect forecasting or unforeseen changes in customer demand.

FIFO and LIFO.

LIFO and FIFO are methods to determine the cost of goods. FIFO, or first-in, first-out, assumes the older inventory is sold first in order to keep inventory fresh.

LIFO, or last-in, first-out, assumes the newer inventory is typically sold first to prevent inventory from going bad.

Reorder point formula.

The reorder point formula calculates the minimum amount of stock a business should have before reordering. A reorder point is usually higher than a safety stock number to factor in lead time.

Batch tracking.

Batch tracking is a quality control technique wherein users can group and monitor similar goods to track inventory expiration or trace defective items back to their original batch.

Consignment inventory.

If you're thinking about your local consignment store here, you're exactly right.

Consignment inventory is when a consigner (vendor or wholesaler) agrees to give a consignee (retailer) their goods without the consignee paying for the inventory upfront. The consigner offering the inventory still owns the goods, and the consignee pays for them only when they sell.

Perpetual inventory management.

Perpetual inventory management is simply counting inventory as soon as it arrives to deliver real-time insights.

It's the most basic type of inventory management system and can be recorded manually on pen and paper or an Excel spreadsheet. Or, by using handheld devices that scan product barcodes and RFID tags, you may use an inventory system that automates inventory balances as soon as stock is moved, sold, used or discarded.

Dropshipping.

Dropshipping is an order fulfillment method in which the supplier ships products directly to the customer. When a store makes a sale, instead of picking the item from their own inventory, they purchase the item from a third party and have it shipped to the consumer.

Lean Manufacturing.

Lean manufacturing is a broad set of management practices that can be applied to any business practice. Its goal is to improve efficiency by eliminating waste and any non-value-adding activities from daily business.

Six Sigma.

Six Sigma is a method that gives companies tools to improve the performance of their business (increase profits) and decrease excess inventory.

Lean Six Sigma.

Lean Six Sigma enhances the tools of Six Sigma, but instead focuses more on increasing word standardization and the flow of business.

Demand forecasting.

Demand forecasting is based on historical sales data to forecast customer demand. Essentially, it's an estimate of the goods and services a company expects customers to purchase in the future.

Cross-docking.

Cross-docking is a technique whereby a supplier truck unloads materials directly into outbound trucks to create a JIT shipping process. This essentially eliminates warehousing, and there is little to no storage in between deliveries.

Bulk shipments.

Bulk shipments is a cost efficient method of shipping in which a business palletizes inventory to ship more at once. To see some examples of effective inventory management in action, check out our BigCommerce Case Studies page, where you can find success stories from both B2C and B2B merchants.

INVENTORY MANAGEMENT FAQS (2 marks)

There are many questions in a broad and complicated topic like inventory management. Here are answers to a few:

What Are the Objectives of Inventory Management?

One objective of inventory management is to keep enough stock to satisfy customers. Another is to invest as little as possible in stock while still earning the most profit.

Why Inventory Management Is Important in the Supply Chain

Inventory management is vital in the supply chain because a company must balance customer demand with storage space and cash limitations. Inventory management provides visibility into the supply chain (procurement, production, fulfillment, etc.) so managers can coordinate lead times for deliveries with production timetables.

How Can Inventory Management Be Improved?

Keeping accurate accounting records and taking regular physical stock counts can improve your inventory management efforts. A system that provides your organization with real-time visibility into inventory can help stakeholders make critical business decisions. You should also be aware of a stock's condition, especially if you're dealing with perishables.

How Inventory Management Affects the Working Capital

Real goods in warehouses tie up working capital until they sell. Making the supply chain more efficient keeps you from holding too much stock. Improving inventory management processes helps you prevent storing, picking and shipping errors that reduce sales.

What Are Inventory Management Policies?

Inventory management policies are plans for how to use inventory to make customers happy and reduce costs. Policies outline such things as the stock management method the company uses.

What Are the Types of Inventory Management Systems?

There are several types of inventory management systems that businesses use depending on how they operate. Three examples are manual inventory, periodic inventory and perpetual inventory. Manual methods are the least sophisticated and least accurate, and perpetual systems are the most sophisticated and most accurate.

- **Manual Inventory System:** This involves physically counting items and recording them on paper or in a spreadsheet. Small businesses may use manual systems.
- **Periodic Inventory System:** Periodic inventory systems include manual and periodic counts. Periodic counts record item details as items move in and out of stock. Barcodes simplify stocktaking. A database contains the records of stock levels and locations.
- **Perpetual Inventory System:** Perpetual inventory systems provide real-time stock data, as they rely on active radio frequency identification (RFID) tags that are always on and sending updates on item movements. Passive RFID tags, meanwhile, use a scanner to send stock information to the database.

What Is Service Level in Inventory Management?

A service level for inventory management is how much a company believes it can successfully store a particular stock.In other words, it's the probability a company will avoid stockouts and support sales.

How Does ERP Help in Inventory Management?

Enterprise resource planning (ERP) is helpful for inventory management because it tracks and provides insights into supply chain operation, accounting and purchasing, consolidating the information and making it visible in one place.

What Is Poor Inventory Management?

Poor inventory management is an imbalance between keeping too much and too little stock. The definition of a perfect balance can change as demand changes: Sales change when trends or seasons change. Poor stock management increases costs and thereby reduces profits.

Objectives of Operations Scheduling

Scheduling is the planning of operations on a daily basis that specifies details related to which job will be done by which work center, the starting and end of an operation or a job, the equipment on which the operation should be done, and who will be responsible for doing, the sequence of job operations on different machines or work centers.

Below are the main objectives or purpose of scheduling:

- **Maximize Resource Utilization:** One area that incurs high costs for a manufacturing company is the poor utilization of all resources. This can be due to a poor schedule that leaves machines idle for long periods of time.

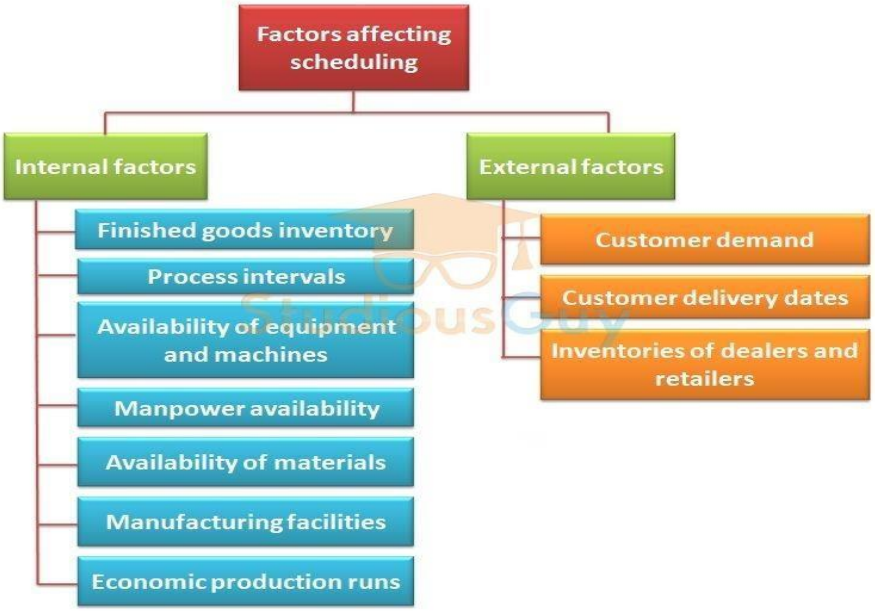
- **Manufacturing Time Reduction:** When a proper schedule is created, your overall production time should be reduced. This is usually because all operations required to make a product will be performed only when they are needed. Therefore, the start to finish time will be shorter as you will have less time between the various operations.
- **Inventory Minimization:** To elaborate on the last point, a shorter manufacturing time usually means that you have less WIP inventory items waiting on availability on a resource. In addition, if your production starts so that it can be completed just before it needs to be shipped out, you will have less inventory to hold on to.
- **Optimizing Efficiency of Labor:** A great production schedule will be one that minimizes the amounts of back and forth and changeovers/setup time on machines. In addition, when workers know which item they are producing next and where the material is coming from, they will be more efficient.
- **Service Level Improvement:** Having an efficient production schedule not only benefits the workers on the shop floor but also the customer service employees. By looking at the schedule, they will know when products will be completed and they will be able to give a more accurate lead time. They will also be able to notify customers in advance in the event that a disruption occurs which would cause jobs products to be late.
- **Increasing Profits and Output:** Overall, having an efficient schedule will increase the number of products that are capable of being produced. This is turn will decrease production costs, as all resources will be utilized optimally. The overall result will be increased profits and increased on-time delivery.

FUNCTIONS OF OPERATIONS SCHEDULING

- **Resource Allocation:** The first part of scheduling operations is to allocate resources to each job. This is different than assigning jobs to departments as not every machine or labor resource is capable of producing each item. This will give you a more realistic picture of the actual capacity you possess.
- **Sequence of Jobs:** The next part is to determine the right sequence of jobs that will be performed on each resource. A common technique used is grouping jobs together as to minimize the amount of setup and changeover required. This could be running jobs of similar color or materials one after the other to reduce machine setup.
- **Start and End Time of Job:** When your operations are scheduled in the right order, you will now have a specific start and end time. For the most accurate schedule, you should consider the different machine run rates for various products and various machines. Knowing when operations are supposed to start and finish will help you notify customers of the status of their order.
- **Maximum Utilization of Plant:** Often, resources are not utilized to their full capacity. This leaves many resources idle for long periods of time which can be costly. One method to improve the overall schedule is to focus on the scheduling of operations on resources that are bottlenecks or that cost a lot to run. This will ensure that those resources are always processing items while upstream and downstream operations are adjusted to limit the number of WIP items.
- **Information on Machines:** Operations scheduling means that you have up-to-date operations on machines and the products that are being produced. Shop floor feedback on the status of operations offers additional visibility on the status of orders.

- **Shop Floor Control:** Having optimized operation schedules ensures that everyone knows what should be started and completed when. This gives additional structure and control over the shop floor operations.

Factors that Affect Scheduling



Through scheduling, the planning phase of production planning and control is finalized. Below are the factors that create an impact on scheduling and are considered before making a scheduling plan.

EXTERNAL FACTORS

These factors are those factors over which an organization's management has no control. These are enforced by the forces that are outside the organization.

These factors include the demand of the customer, Delivery dates of Customers, and Inventories of Dealers and Retailers. These factors are elaborated below in detail:

Demand for Customer

The sales forecasting department estimates this demand. Scheduling depends on the expected sales forecasting of particular products in the process of continuous production.

Delivery Dates of Customer

In a manufacturing concern where there is a mass or continuous production with demand at a seasonal level, the scheduling should be done to generate a balanced production in the whole year by minimizing inventory stock with a constant production. If the demand is seasonal and production is intermittent, then adjustments can be done by providing delivery of consumer orders on delivery dates that are agreeable.

Inventories of Dealers and Retailers

This situation occurs in the continuous production of standardized goods. Generally, the stock is maintained at a certain level by dealers and retailers. The basis of scheduling in such a case should be the position of stock with dealers and retailers.

Internal Factors

There should be a manipulation of factors that are in direct control of management and this manipulation should be done in such a way that goals of production can be obtained in the most effective and economic way.

Internal factors include the following factors:

Inventory of Finished Goods

In the case of made to stock production, there is a need to adjust operations scheduling to the inventory of finished goods with the dealers. Scheduling should be performed by considering the fluctuations in the stock holding.

Process Intervals

These are the time intervals included in processing finished goods from raw material and from every assembly.

Availability of Equipment and Machines

Varying production capacities are there for different equipment and machines. Also, through machine load charts, the occupancy scheduling can be made for these machines and equipment.

Manpower Availability

The availability of the manpower should be considered while doing scheduling. To adjust the production rush, from the hiring of a temporary worker to overtime working should be considered.

Availability of Materials

The production flow may get hampered due to stock out circumstances. To ensure continuous production, scheduling should be facilitated by maintaining proper stock levels.

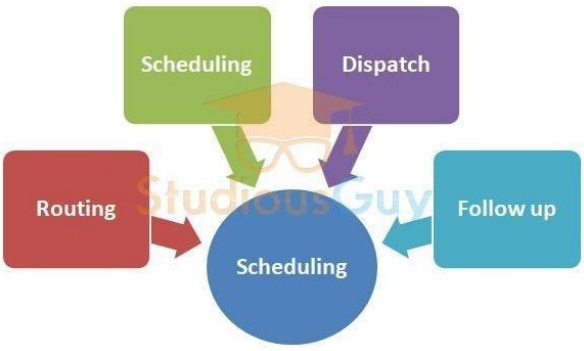
Manufacturing Facilities

To facilitate the scheduling function, manufacturing facilities such as material handling services, power requirements, storekeeping, and other related services should be given in appropriate quantities. This also helps in the smooth flow of production.

Economic Production Runs

Both set up cost and the carrying cost are equalized under economic production.

Scheduling Activity under Production Planning and Control (PPC)



Below scheduling activities are covered under PPC:

Routing

Routing or planning activity determines the best possible route to manufacture a product. A plant's workflow is defined through routing and also, other activities such as the type of work,

place to perform the work, and way to do that are also determined by routing. For each job, route sheets are made.

Scheduling

Scheduling includes determining the sequence of processing jobs that will be carried out at each work center. It also establishes the start and the end time of these jobs.

Dispatch

Through dispatch, production to commerce is allowed by material and work order supply.

Follow up

This includes monitoring progress and making corrections for the purpose of minimizing deviations.

Scheduling Strategies

Different organizations have different scheduling strategies as it is based on the production quantity, type, and size of production, organization's policy, priorities, etc. These strategies are mostly related to job shop production because more problem arises in the case of the same plant carries the production of more than one product. Classifications include detailed scheduling, cumulative scheduling, cumulative-detailed scheduling, and priority decision rules.

Detailed Scheduling

Detailed scheduling is done for ensuring the completion of the orders processed to the job floor by the due date. To achieve this, different shop floor resources such as material, machine, tools, and people are allocated in a detailed way. The process is completed once the order has been closed by completing it.

Cumulative Scheduling

The pooling of customer orders is done for making a cumulative workload and further, the task of matching with the capacity is performed. The allocation of the work is done further by ensuring the allocation of immediate periods to maximum capacity.

Cumulative-detailed Combination

Both previous strategies of the organization and work load's flexible nature are combined in this. Capacity can be planned by making projections of cumulative workload as required.

Priority Decision Rules

The matter of prioritizing arises at the time of execution of a set of orders. These priority decision rules are guidelines for scheduling utilized independently or in collaboration with any one of the above strategies.

Scheduling Guidelines

Below are the guidelines for scheduling:

Realistic schedule: There should be a realistic approach to scheduling rather than an idealistic one while considering all the practical possibilities.

Allowing adequate time for operations: Appropriate and enough time should be permitted for production.

Adequate time allocation from starting to the end of operations: This includes allowing sufficient time for queuing and transit of WIP (work in progress).

Not to release all available jobs to the shop: The capacity is overloaded if all the available jobs are released once they are received. Also, it results in an increase in the lead time and excess of WIP inventory.

Only selected work centers to be loaded: Only those work centers should be selected for operations that are fit.

Allowing required changes: The schedule should be flexible enough to cope up with required changes and any changes in the products.

Scheduling Approaches

Two types of approaches are there to scheduling i.e. forward scheduling and backward scheduling. These are utilized to maintain the lead time for manufacturing at a minimum level and also, to ensure the supply of the products to customers as soon as possible.

Forward Scheduling

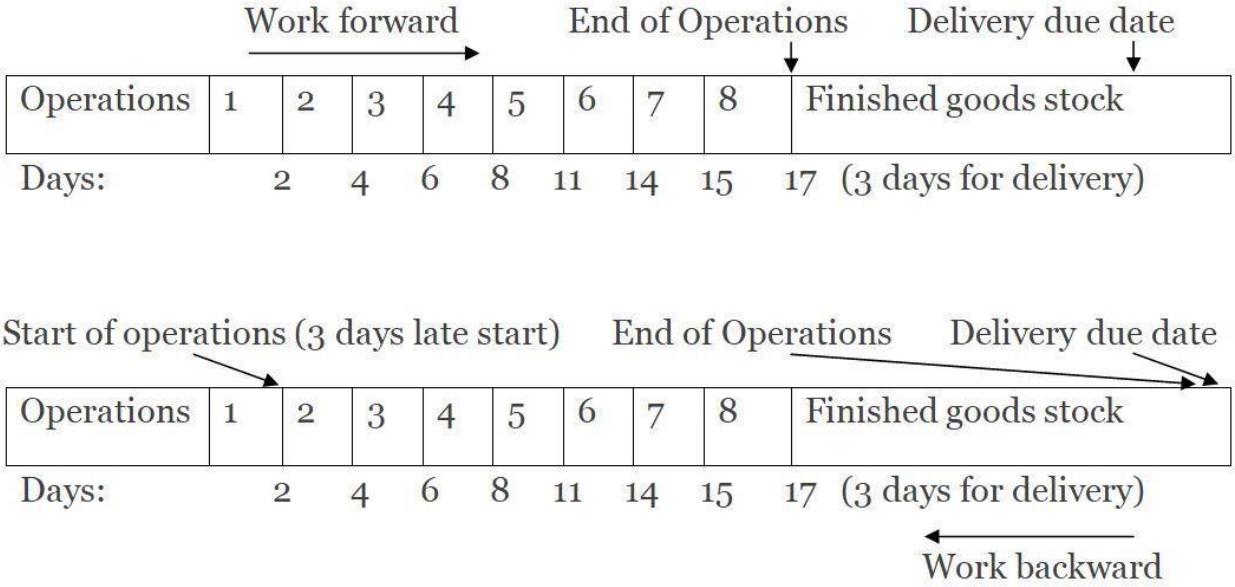
This approach includes processing the customer orders on an immediate basis once they are received despite their due dates are quite far. A planned order release date is selected by the scheduler in the forward scheduling.

Backward Scheduling

This scheduling starts with a planned receipt date or due date. It moves backward in time based on the required processing time. In this approach, the processing of customer orders is done quite late for the purpose of completing and delivering the orders on exact due dates. To determine the starting time of the processing job, the total days required for processing are set back from the date of completion.

For example, if it takes 20 days to process all processes of a component, the execution of the forward and backward scheduling can be done as mentioned below:

Forward and backward scheduling



The methodology of Scheduling (Quantitative)

Different types of methodologies and scheduling are used in production. Methods are used based on different factors such as products, industry type, organization, and sophistication level in the production. Scheduling methodology can be categorized into priority decision rules and charts and boards.

Charts and Boards

These include Gantt load chart, Schedule boards, Gantt progress chart, and Computer graphics. Above charts and boards are briefly discussed below:

Gantt Load Chart

This chart depicts the total cumulative workload allotted to each work center in a manufacturing plant. Gantt load chart is a graph that shows the estimated total and individual workload related to each work center on a specific time scale.

Gantt chart Benefits

- It is easy to understand the total workload represented graphically in the chart as it is clear and simple.
- It indicates that more resources are required in the situation when much more load is there at a single work center. If the work centers are overloaded, employees working on low-load work centers may be transferred to these high-load work centers on a temporary basis.

Gantt chart limitations

- These charts don't include disruptions and delays that occur during work at work centers.
- There is no information related to the due date related requirements of each job.
- There is a need for updating chat periodically for new jobs.

Gantt schedule and Progress chart

This chart shows each job's scheduled starting and finishing dates. It also reveals the present status of each job.

Schedule boards

Staff working on the shop floor is required to be familiar with the information related to the way they are processing production-based components and a simple schedule board can be used to reflect this in the production shops. The progress department updates the content of schedule boards on daily basis. These boards include simple bar graphs and the actual status of products or components are represented on these graphs.

Computer Graphics

Mechanical charts and boards have been replaced by computer graphics. Production planning and control department is able to keep track of n number of items with the help of computers and also, the schedule can be revised through these computer graphics.

Priority Decision Rules

Priority decision rules are considered the systematic procedures through which priorities are assigned to jobs on a waiting list, and sequence is determined to process jobs. The main criteria through which rules are applied include set up costs, in-process inventory, average total jobs waiting in a queue, idle time related to labor and machine, the average time required to complete a job, etc.

Classifications of priority decision rules

This includes below priority decision rules:

- Single-criteria rules
- Combined criteria rules or rule of Johnson
- Critical ratio scheduling
- Index method of scheduling
- Critical path method

The above rules are elaborated below:

Single-criteria Rules

In this, an important and single criterion is considered while assigning different jobs to the production division. These criteria consist of:

FCFS (First come first served): Means the job enters or arrives first at a work center is considered and processed by scheduling first.

EDD (Earliest due date): This includes selecting that job first which has the earliest due date.

Least slack available for production: The waiting job, that has the least slack time is given priority. To calculate slack time, the difference between the left time in completion of the job and the time length of its operation is determined. For instance, if 5 days are required to complete a job and the remaining time is 7 days, then the difference of 2 days would be considered as slack.

Shortest processing time: This includes processing that job first in which the least of shortest time is required.

Longest processing time: Consists of processing that job first in which the longest time is required.

Preferred customer order: This includes giving priority to those orders that are received from favorite customers.

Random selection: The selection of jobs is on a random basis.

The below example shows the practical aspect of using priority rules for scheduling. Different methods of production planning and control (PPC) are also explained in this. The below table includes the processing time (in days) and the due date (in days):

Data for above example

Job	A	B	C	D	E
Processing time (in days)	7	20	18	12	16
Due date (in days)	9	25	21	15	17

Based on the above data, we will determine the following:

1. The job sequence as per the shortest processing time
2. The total completion time
3. Each day's average number of jobs in the system
4. Job sequencing through a short processing time
5. Average lateness

Let's determine the above points one by one as per the below calculations:

1. In the above table, the sequence of jobs is ABCDE; whereas, the sequence of jobs according to the shortest processing or flow time is ADECB.

Calculation of processing time days and late days

Sequence of job	Processing time (in days)	Total processing or flow time (in days)	Due days from now	Late days
A	7	7	9	-2
B	20	27(7+20)	25	2
C	18	45(27+18)	21	24
D	12	57(45+12)	15	42
E	16	73(57+16)	17	56
Total	**73**	**209**		

2. Total completion time will be equal to total processing days i.e. 73 days.

3. Each day's average number of jobs running in the system at a time is equal to (total cumulative processing or flow time in the sequence) / (total process days needed). In this, at the time of processing of first job A, rest jobs i.e. B, C, D, E are in waiting for their turn. In the same way, once the first job is completed, the processing of the second job B will start, and the rest three jobs C, D, E are waiting. This elimination of jobs in the queue will continue until all five

jobs are processed and completed. So, the average total jobs in the system on daily basis would be calculated as under:
[(5*7) + (4*20) + (3*18) + (2*12) + (1*16)] / (73)
=2.86 jobs in the system per day.
4. Job sequencing through a short processing time can be done by putting the processing time in ascending order in the above table. The ascending order will come as ADECB. This is shown in the below table:

Calculation of processing or flow time days and due days

Waiting job-basis on Short processing time (SPT)	Processing time (in days)	Total processing or flow time (in days)	Due days
A	7	7	9
D	12	19(7+12)	15
E	16	35(19+16)	17
C	18	53(35+18)	21
B	20	73(53+20)	25
Total	**73**	**187**	

The average mean or flow time is equal to the total cumulative processing or flow time (in days) / Total number of sequences= 187/5= 37.4 days.
This reveals that it takes 37.4 days are the average job in production.
5. Average job lateness will be equal to cumulative late (in days) of sequences
= (0+2+24+42+56) / 5 = 24.8 days. As the value of A is (-2) in lateness, it means that job A is produced 2 days earlier. So, the lateness would be zero.

Combined Criteria Rules or Rule of Johnson
The rule of Johnson is utilized in determining the sequence of order that is required to process a series of jobs on pre-defined machines. This sequencing is based on the aggregate time that is required to finish all the jobs and it should be kept at a minimum. This rule is a procedure to minimize the total cycle time required to schedule a group of jobs on two work centers. There are two main benefits to sequence such a group of jobs for minimizing the time i.e.

- The minimum time is involved in the completion of a group of jobs
- It maximizes the use of two station flow shop

Johnson's rule can be adopted by following the below steps:

- Listing of the time of processing or operation from "n" jobs on the two different machines or work centers.
- Scanning of all the times related to processing or operation for the "n" jobs on both work centers or machines and selecting the processing or operation having the shortest time in any of the work centers.
- In case, the shortest processing time is related to a job on the first machine or work center, that job will be placed first in the sequence. The job will be placed last in the sequence if the shortest processing time is for a job at the second work center or machine.
- In the next step, the job assigned will be removed from further consideration. In other words, both times will be crossed off for the assigned job.
- Repetition of 2, 3, and 4 steps until the process of assigning all jobs into the sequence is completed.

For example, two machines are occupied to work for six jobs that are required to be produced and the time for two operations on these two machines are given in the below table for all the six jobs. These jobs will put in a sequence for scheduling through Johnson's rule and the best sequence to schedule these jobs will be determined.

Data for above example

Job	**Time in hours on Machine A**	**Time in hours on Machine B**
1	8	10
2	15	13
3	10	14
4	7	9
5	14	8
6	16	6

Now, we will apply Johnson's rule on the above machines by following the below steps:

1. At first, the shortest processing time will be taken among all the above processing time irrespective of the machine. In the above table, the shortest time is 6 hours on machine B and job 6. So, this job will be placed in last (as late as possible).

					6

2. The next shortest time is 7 hours on machine A and for job 4. So, this job will be placed as early as possible.

4					6

3. Now, both the 1st and 5th jobs contain the same next shortest time i.e. 8 hours. So, we will select anyone first. Among the remaining jobs, job 1 will be placed as early as possible.

4	1				6

4. In the above step 3, the 5th job also has the same shortest time of 8 hours, so, it will be placed as late as possible among the pending slots.

4	1			5	6

5. The next shortest time is 9 hours on machine B and for job 4. It will be placed as early as possible among the remaining jobs.

4	1	3		5	6

6. The remaining job of 2 will be placed in the vacant slot as shown below:

4	1	3	2	5	6

So, through the above analysis; sequence 4, 1, 3, 2, 5, 6 is considered the best sequence for scheduling jobs.

Critical Ratio Scheduling

This includes establishing and maintaining priority among different jobs. If the critical ratio is more than one, the completion of the job is ahead of schedule. If the critical ratio is equal to unity, it means that there is a need for watching the job closely. Less than unity indicates the need for adopting special measures to finish the job on the due date. For each job, critical ratio quantity is calculated and the priority is given to the jobs that have lower critical ratios and are processed first.

Critical Ratio= Time left for a job's due date/ Time required to finish the job

For example, there are four jobs in the below table and include due dates, operation time, remaining operations (in numbers), and shop remaining time. The critical ratio schedule will be calculated as under:

Data for calculating Critical ratio

Job	Operating time (hours)	Due days of remaining time	Remaining Operations (in numbers)	Remaining shop time	Critical Ratio
1	6	15	9	10	1.5
2	9	12	3	11	1.1
3	7	18	10	18	1
4	15	10	5	12	0.83

As the critical ratio is calculated by dividing due days of the remaining time and remaining shop time, so, first reading would be 15/10= 1.5. Similar calculations are done for other jobs i.e. 2, 3, and 4. The readings of the critical ratio are filled in the respective column. The sequence is arranged by putting the lowest critical ratio first and then following the ascending order. So, the job loading sequence is 4,3,2,1.

Index Method of Scheduling

This includes assigning a job to the best machine until its capacity is consumed totally. After this, the rest jobs are transferred to the next available best machine. In the index method of scheduling, until and unless all the jobs are fully loaded as per capacity, assigning the jobs to the best work center continues.

For example, the index method is used to sort out the below problem of shop loading:

Data to solve the issue through Index method of scheduling

Job	WC1	WC2	WC3	WC4
A	12	11	**10**	14
B	4	5	6	**3**
C	26	20	**15**	17
D	**6**	8	9	8
E	16	12	14	23
Number of days available	24	24	24	24

The indices are shown in the following table. The days corresponding to an assigned job are underlined with bold letters. This predicts each work center's minimum number of days.

Indices of above example

	WC1		WC2		WC3		WC4	
	Days	Index	Days	Index	Days	Index	Days	Index
A	12	1.2	11	1.1	**10**	1	14	1.4
B	4	1.33	5	1.66	6	2	**3**	1
C	26	1.73	20	1.33	**15**	1	17	1.13
D	**6**	1	8	1.33	9	1.5	8	1.33
E	16	1.33	**12**	1	14	1.16	23	1.92
Number of days available	24		24		24		24	
Days assign	**6**		**12**		**25**		**3**	

Indices are based on:

Job A contains minimum processing time in work station 3 i.e. 10 days, and so, the index of this one is 1. The processing times of 12, 11, and 14 days at work centers 1, 2, and 4 respectively are divided by 10 to depict indices. The same process is continued for all jobs i.e. B, C, D, and E, and their indices are shown in the column.

Jobs are assigned further to work centers as per the index equal to 1 and shown as below:

Jobs	A	B	C	D	E
Work Center assigned	3	4	3	1	2

Critical Path Method

This method is utilized to schedule unique and big projects that include complicated relationships between different activities. This method includes drawing the network of work centers and processing routes in graphical form. The critical path is identified by drafting PERT/CPM charts.

Scheduling in Services

The scheduling followed in manufacturing is different from the scheduling used in services. These differences create an impact directly on the scheduling. These differences include the following:

- Inventories can't be created by service operations for the purpose of providing a buffer for uncertainties related to demand.
- The accurate prediction of the demand in service operations is not possible.
- Certain distortions may occur in scheduling due to considering the demand for service as an unplanned event.
- It is a challenge and a bit crucial sometimes to provide the desired manpower and skills to meet the sudden demand in scheduling a service-related activity.

Scheduling Demand of Customers

Generally, the capacity of the service center is fixed, but its demand will keep changing. Moreover, it is difficult to forecast the demand for service activities in advance and certain

problems may arise in scheduling such varying demand. It is required for the scheduler to adopt systems so that timely service can be provided and the capacity can be utilized to its maximum extent.

Generally, a scheduler uses three methods in services i.e. Backlogs, Reservations, and Appointments.

Backlogs

In order to plan better capacity, service centers make a provision for allowing backlogs. Priority rules can be used to identify the order for the next processing. The general rule is FCFS (first come first served).

Reservations

Generally, the advance reservations are there in case of services provided by different service industries such as travels, hospitals, etc. A reservation system is considered if the customers look for need-based service facilities.

Appointments

This includes specifying the customer with the service time. This also includes the benefits of customized service and high capacity utilization. For instance, surgery in hospitals or appointments with doctors, etc. requires planning of service activities for customers.

WHAT IS THE THEORY OF CONSTRAINTS?

The Theory of Constraints is a methodology for identifying the most important limiting factor (i.e., constraint) that stands in the way of achieving a goal and then systematically improving that constraint until it is no longer the limiting factor. In manufacturing, the constraint is often referred to as a bottleneck.

The Theory of Constraints takes a scientific approach to improvement. It hypothesizes that every complex system, including manufacturing processes, consists of multiple linked activities, one of which acts as a constraint upon the entire system (i.e., the constraint activity is the "weakest link in the chain").

So what is the ultimate goal of most manufacturing companies? To make a profit – both in the short term and in the long term. The Theory of Constraints provides a powerful set of tools for helping to achieve that goal, including:

- **The Five Focusing Steps:** a methodology for identifying and eliminating constraints
- **The Thinking Processes:** tools for analyzing and resolving problems
- **Throughput Accounting:** a method for measuring performance and guiding management decisions

Dr. Eliyahu Goldratt conceived the Theory of Constraints (TOC), and introduced it to a wide audience through his bestselling 1984 novel, "The Goal". Since then, TOC has continued to evolve and develop, and today it is a significant factor within the world of management best practices.

One of the appealing characteristics of the Theory of Constraints is that it inherently prioritizes improvement activities. The top priority is always the current constraint. In environments where there is an urgent need to improve, TOC offers a highly focused methodology for creating rapid improvement.

A successful Theory of Constraints implementation will have the following benefits:

- Increased Profit: the primary goal of TOC for most companies
- Fast Improvement: a result of focusing all attention on one critical area – the system constraint
- Improved Capacity: optimizing the constraint enables more product to be manufactured
- Reduced Lead Times: optimizing the constraint results in smoother and faster product flow
- Reduced Inventory: eliminating bottlenecks means there will be less work-in-process

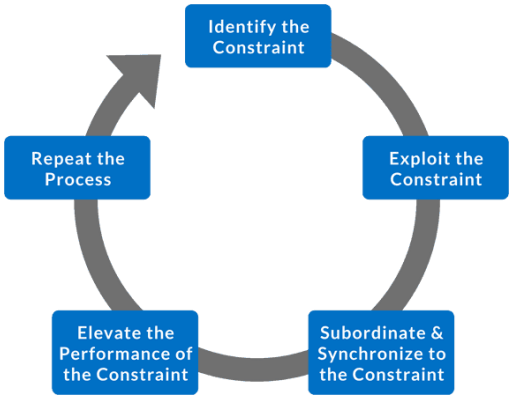
BASICS OF THEORY OF CONSTRAINTS Core Concept

The core concept of the Theory of Constraints is that every process has a single constraint and that total process throughput can only be improved when the constraint is improved. A very important corollary to this is that spending time optimizing non-constraints will not provide significant benefits; only improvements to the constraint will further the goal (achieving more profit).

Thus, TOC seeks to provide precise and sustained focus on improving the current constraint until it no longer limits throughput, at which point the focus moves to the next constraint. The underlying power of TOC flows from its ability to generate a tremendously strong focus towards a single goal (profit) and to removing the principal impediment (the constraint) to achieving more of that goal. In fact, Goldratt considers focus to be the essence of TOC.

The Five Focusing Steps

The Theory of Constraints provides a specific methodology for identifying and eliminating constraints, referred to as the Five Focusing Steps. As shown in the following diagram, it is a cyclical process.



The Theory of Constraints uses a process known as the Five Focusing Steps to identify and eliminate constraints (i.e., bottlenecks).

The Five Focusing Steps are further described in the following table.

Step	**Objective**
Identify	Identify the current constraint (the single part of the process that limits the rate at which the goal is achieved).
Exploit	Make quick improvements to the throughput of the constraint using existing resources (i.e., make the most of what you have).
Subordinate	Review all other activities in the process to ensure that they are aligned with and truly support the needs of the constraint.
Elevate	If the constraint still exists (i.e., it has not moved), consider what further actions can be taken to eliminate it from being the constraint. Normally, actions are continued at this step until the constraint has been "broken" (until it has moved somewhere else). In some cases, capital investment may be required.
Repeat	The Five Focusing Steps are a continuous improvement cycle. Therefore, once a constraint is resolved the next constraint should immediately be addressed. This step is a reminder to never become complacent – aggressively improve the current constraint…and then immediately move on to the next constraint.

The Thinking Processes

The Theory of Constraints includes a sophisticated problem solving methodology called the Thinking Processes. The Thinking Processes are optimized for complex systems with many interdependencies (e.g., manufacturing lines). They are designed as scientific "cause and effect" tools, which strive to first identify the root causes of undesirable effects (referred to as UDEs), and then remove the UDEs without creating new ones.

The Thinking Processes are used to answer the following three questions, which are essential to TOC:

- What needs to be changed?
- What should it be changed to?
- What actions will cause the change?

Examples of tools that have been formalized as part of the Thinking Processes include:

Tool	**Role**	**Description**
Current Reality Tree	Documents the current state.	Diagram that shows the current state, which is unsatisfactory and needs improvement. When creating the diagram, UDEs (symptoms of the problem) are identified and traced back to their root cause (the underlying problem).
Evaporating Cloud Tree	Evaluates potential improvements.	Diagram that helps to identify specific changes (called injections) that eliminate UDEs. It is particularly useful for resolving conflicts between different approaches to solving a problem. It is used as part of the process for progressing from the Current Reality Tree to the Future Reality Tree.
Future Reality Tree	Documents the future state.	Diagram that shows the future state, which reflects the results of injecting changes into the system that are designed to eliminate UDEs.
Strategy and Tactics Tree	Provides an action plan for improvement.	Diagram that shows an implementation plan for achieving the future state. Creates a logical structure that organizes knowledge and derives tactics from strategy. Note: this tool is intended to replace the formerly used Prerequisite Tree in the Thinking Processes.

Throughput Accounting

Throughput Accounting is an alternative accounting methodology that attempts to eliminate harmful distortions introduced from traditional accounting practices – distortions that promote behaviors contrary to the goal of increasing profit in the long term.

In traditional accounting, inventory is an asset (in theory, it can be converted to cash by selling it). This often drives undesirable behavior at companies – manufacturing items that are not truly needed. Accumulating inventory inflates assets and generates a "paper profit" based on inventory that may or may not ever be sold (e.g., due to obsolescence) and that incurs cost as it sits in storage. The Theory of Constraints, on the other hand, considers inventory to be a liability – inventory ties up cash that could be used more productively elsewhere.

"The Theory of Constraints, on the other hand, considers inventory to be a liability – inventory ties up cash that could be used more productively elsewhere.

In traditional accounting, there is also a very strong emphasis on cutting expenses. The Theory of Constraints, on the other hand, considers cutting expenses to be of much less importance than increasing throughput. Cutting expenses is limited by reaching zero expenses, whereas increasing throughput has no such limitations.

These and other conflicts result in the Theory of Constraints emphasizing Throughput Accounting, which uses as its core measures: Throughput, Investment, and Operating Expense.

Core Measures	**Definition**
Throughput	The rate at which customer sales are generated less truly variable costs (typically raw materials, sales commissions, and freight). Labor is not considered a truly variable cost unless pay is 100% tied to pieces produced.
Investment	Money that is tied up in physical things: product inventory, machinery and equipment, real estate, etc. Formerly referred to in TOC as Inventory.
Operating Expense	Money spent to create throughput, other than truly variable costs (e.g., payroll, utilities, taxes, etc.). The cost of maintaining a given level of capacity.

In addition, Throughput Accounting has four key derived measures: Net Profit, Return on Investment, Productivity, and Investment Turns.

Net Profit = Throughput − Operating Expenses

Return on Investment = Net Profit / Investment

Productivity = Throughput / Operating Expenses

Investment Turns = Throughput / Investment

In general, management decisions are guided by their effect on achieving the following improvements (in order of priority):

- Will Throughput be increased?
- Will Investment be reduced?
- Will Operating Expenses be reduced?

The strongest emphasis (by far) is on increasing Throughput. In essence, TOC is saying to focus less on cutting expenses (Investment and Operating Expenses) and focus more on building sales (Throughput).

Drum-Buffer-Rope

Drum-Buffer-Rope (DBR) is a method of synchronizing production to the constraint while minimizing inventory and work-in-process.

The **"Drum"** is the constraint. The speed at which the constraint runs sets the "beat" for the process and determines total throughput.

The **"Buffer"** is the level of inventory needed to maintain consistent production. It ensures that brief interruptions and fluctuations in non-constraints do not affect the constraint. Buffers represent time; the amount of time (usually measured in hours) that work-in-process should arrive in advance of being used to ensure steady operation of the protected resource. The more variation there is in the process the larger the buffers need to be. An alternative to large buffer inventories is sprint capacity (intentional overcapacity) at non-constraints. Typically, there are two buffers:

- Constraint Buffer: immediately before the constraint; protects the constraint
- Customer Buffer: at the very end of the process; protects the shipping schedule

The **"Rope"** is a signal generated by the constraint indicating that some amount of inventory has been consumed. This in turn triggers an identically sized release of inventory into the process. The role of the rope is to maintain throughput without creating an accumulation of excess inventory.

THE NATURE OF CONSTRAINTS

What are Constraints?

Constraints are anything that prevents the organization from making progress towards its goal. In manufacturing processes, constraints are often referred to as bottlenecks. Interestingly,

constraints can take many forms other than equipment. There are differing opinions on how to best categorize constraints; a common approach is shown in the following table.

Constraint	Description
Physical	Typically equipment, but can also be other tangible items, such as material shortages, lack of people, or lack of space.
Policy	Required or recommended ways of working. May be informal (e.g., described to new employees as "how things are done here"). Examples include company procedures (e.g., how lot sizes are calculated, bonus plans, overtime policy), union contracts (e.g., a contract that prohibits cross-training), or government regulations (e.g., mandated breaks).
Paradigm	Deeply engrained beliefs or habits. For example, the belief that "we must always keep our equipment running to lower the manufacturing cost per piece". A close relative of the policy constraint.
Market	Occurs when production capacity exceeds sales (the external marketplace is constraining throughput). If there is an effective ongoing application of the Theory of Constraints, eventually the constraint is likely to move to the marketplace.

There are also differing opinions on whether a system can have more than one constraint. The conventional wisdom is that most systems have one constraint, and occasionally a system may have two or three constraints.

In manufacturing plants where a mix of products is produced, it is possible for each product to take a unique manufacturing path and the constraint may "move" depending on the path taken. This environment can be modeled as multiple systems – one for each unique manufacturing path.

Policy Constraints

Policy constraints deserve special mention. It may come as a surprise that the most common form of constraint (by far) is the policy constraint.

Since policy constraints often stem from long-established and widely accepted policies, they can be particularly difficult to identify and even harder to overcome. It is typically much easier for an external party to identify policy constraints, since an external party is less likely to take existing policies for granted.

When a policy constraint is associated with a firmly entrenched paradigm (e.g., "we must always keep our equipment running to lower the manufacturing cost per piece"), a significant investment

in training and coaching is likely to be required to change the paradigm and eliminate the constraint.

Policy constraints are not addressed through application of the Five Focusing Steps. Instead, the three questions discussed earlier in the Thinking Processes section are applied:

- What needs to be changed?
- What should it be changed to?
- What actions will cause the change?

The Thinking Processes are designed to effectively work through these questions and resolve conflicts that may arise from changing existing policies.

TOC Example

An excellent way to deepen your understanding of the Theory of Constraints is to walk through a simple implementation example. In this example, the Five Focusing Steps are used to identify and eliminate an equipment constraint (i.e., bottleneck) in the manufacturing process.

Step One – Identify the Constraint

In this step, the manufacturing process is reviewed to identify the constraint. A simple but often effective technique is to literally walk through the manufacturing process looking for indications of the constraint.

Item	Description
WIP	Look for large accumulations of work-in-process on the plant floor. Inventory often accumulates immediately before the constraint.
Expedite	Look for areas where process expeditors are frequently involved. Special attention and handholding are often needed at the constraint to ensure that critical orders are completed on time.
Cycle Time	Review equipment performance data to determine which equipment has the longest average cycle time. Adjust out time where the equipment is not operating due to external factors, such as being starved by an upstream process or blocked by a downstream process. Although such time affects throughput, the time loss is usually not caused or controlled by the starved/blocked equipment.
Demand	Ask operators where they think equipment is not keeping up with demand. Pay close attention to these areas, but also look for other supporting indicators.

The deliverable for this step is the identification of the single piece of equipment that is constraining process throughput.

Step Two – Exploit the Constraint

In this step, the objective is to make the most of what you have – maximize throughput of the constraint using currently available resources. The line between exploiting the constraint (this step) and elevating the constraint (the fourth step) is not always clear. This step focuses on quick wins and rapid relief; leaving more complex and substantive changes for later.

Item	**Description**
Buffer	Create a suitably sized inventory buffer immediately in front of the constraint to ensure that it can keep operating even if an upstream process stops.
Quality	Check quality immediately before the constraint so only known good parts are processed by the constraint.
Continuous Operation	Ensure that the constraint is continuously scheduled for operation (e.g., operate the constraint during breaks, approve overtime, schedule fewer changeovers, cross-train employees to ensure there are always skilled employees available for operating the constraint).
Maintenance	Move routine maintenance activities outside of constraint production time (e.g., during changeovers).
Offload (Internal)	Offload some constraint work to other machines. Even if they are less efficient, the improved system throughput is likely to improve overall profitability.
Offload (External)	Offload some work to other companies. This should be a last resort if other techniques are not sufficient to relieve the constraint.

The deliverable for this step is improved utilization of the constraint, which in turn will result in improved throughput for the process. If the actions taken in this step "break" the constraint (i.e., the constraint moves) jump ahead to Step Five. Otherwise, continue to Step Three.

Step Three – Subordinate and Synchronize to the Constraint

In this step, the focus is on non-constraint equipment. The primary objective is to support the needs of the constraint (i.e., subordinate to the constraint). Efficiency of non-constraint equipment is a secondary concern as long as constraint operation is not adversely impacted.

By definition, all non-constraint equipment has some degree of excess capacity. This excess capacity is a virtue, as it enables smoother operation of the constraint. The manufacturing process is purposely unbalanced:

Item	Description
Upstream	Upstream equipment has excess capacity that ensures that the constraint buffer is continuously filled (but not overfilled) so that the constraint is never "starved" by the upstream process.
Downstream	Downstream equipment has excess capacity that ensures that material from the constraint is continually processed so the constraint is never "blocked" by the downstream process.

Some useful techniques for this step include:

Item	Description
DBR	Implement DBR (Drum-Buffer-Rope) on the constraint as a way of synchronizing the manufacturing process to the needs of the constraint.
Priority	Subordinate maintenance to the constraint by ensuring that the constraint is always the highest priority for maintenance calls.
Sprint	Add sprint capacity to non-constraint equipment to ensure that interruptions to their operation (e.g., breakdowns or material changes) can quickly be offset by faster operation and additional output.
Steady Operation	Operate non-constraint equipment at a steady pace to minimize stops. Frequent inertial changes (i.e., stops and speed changes) can increase wear and result in breakdowns.

The deliverable for this step is fewer instances of constraint operation being stopped by upstream or downstream equipment, which in turn results in improved throughput for the process. If the actions taken in this step "break" the constraint (i.e., the constraint moves) jump ahead to Step Five. Otherwise, continue to Step Four.

Step Four – Elevate Performance of the Constraint

In this step, more substantive changes are implemented to "break" the constraint. These changes may necessitate a significant investment of time and/or money (e.g., adding equipment or hiring

more staff). The key is to ensure that all such investments are evaluated for effectiveness (preferably using Throughput Accounting metrics).

Item	Description
Performance Data	Use performance data (e.g., Overall Equipment Effectiveness metrics plus downtime analytics) to identify the largest sources of lost productive time at the constraint.
Top Losses	Target the largest sources of lost productive time, one-by-one, with cross-functional teams.
Reviews	Implement ongoing plant floor reviews within shifts (a technique called Short Interval Control) to identify tactical actions that will improve constraint performance.
Setup Reduction	Implement a setup reduction program to reduce the amount of productive time lost to changeovers.
Updates/Upgrades	Evaluate the constraint for potential design updates and/or component upgrades.
Equipment	Purchase additional equipment to supplement the constraint (a last resort).

The deliverable for this step is a significant enough performance improvement to break the constraint (i.e., move the constraint elsewhere).

Step Five – Repeat the Process

In this step, the objective is to ensure that the Five Focusing Steps are not implemented as a one-off improvement project. Instead, they should be implemented as a continuous improvement process.

Item	Description
Constraint Broken	If the constraint has been broken (the normal case), recognize that there is a new constraint. Finding and eliminating the new constraint is the new priority (restart at Step One).
Constraint Not Broken	If the constraint has not been broken, recognize that more work is required, and a fresh look needs to be taken, including verifying that the constraint has been

Item	Description
	correctly identified (restart at Step One).

This step also includes a caution…beware of inertia. Remain vigilant and ensure that improvement is ongoing and continuous. The Five Focusing Steps are kind of like "Whac-A-Mole"…pound one constraint down and then move right on to the next!

INTEGRATING WITH LEAN

Contrasting Theory of Constraints and Lean Manufacturing

The Theory of Constraints and Lean Manufacturing are both systematic methods for improving manufacturing effectiveness. However, they have very different approaches:

- The Theory of Constraints focuses on identifying and removing constraints that limit throughput. Therefore, successful application tends to increase manufacturing capacity.
- Lean Manufacturing focuses on eliminating waste from the manufacturing process. Therefore, successful application tends to reduce manufacturing costs.

Both methodologies have a strong customer focus and are capable of transforming companies to be faster, stronger, and more agile. Nonetheless, there are significant differences, as highlighted in the following table.

What?	Theory of Constraints	Lean Manufacturing
Objective	Increase throughput.	Eliminate waste.
Focus	Singular focus on the constraint (until it is no longer the constraint).	Broad focus on the elimination of waste from the manufacturing process.
Result	Increased manufacturing capacity.	Reduced manufacturing cost.
Inventory	Maintain sufficient inventory to maximize throughput at the constraint.	Eliminate virtually all inventory.
Line Balancing	Create imbalance to maximize throughput at the constraint.	Create balance to eliminate waste (excess capacity).
Pacing	Constraint sets the pace (Drum-Buffer-Rope).	Customer sets the pace (Takt Time).

From the perspective of the Theory of Constraints, it is more practical and less expensive to maintain a degree of excess capacity for non-constraints (i.e., an intentionally unbalanced line) than to try to eliminate all sources of variation (which is necessary to efficiently operate a balanced line). Eliminating variation is still desirable in TOC; it is simply given less attention than improving throughput.

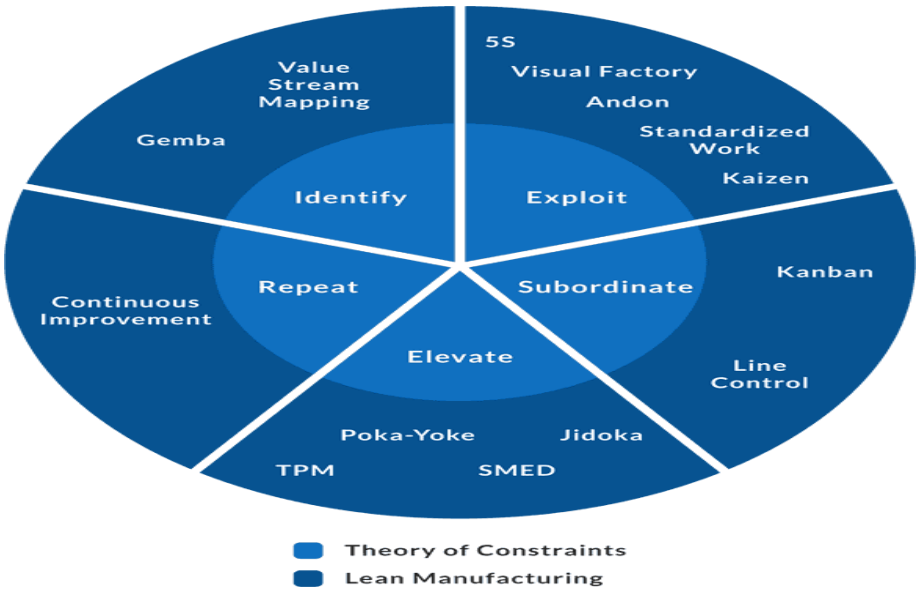
Combining Theory of Constraints and Lean Manufacturing

One of the most powerful aspects of the Theory of Constraints is its laser-like focus on improving the constraint. While Lean Manufacturing can be focused, more typically it is implemented as a broad-spectrum tool.

In the real world, there is always a need to compromise, since all companies have finite resources. Not every aspect of every process is truly worth optimizing, and not all waste is truly worth eliminating. In this light, the Theory of Constraints can serve as a highly effective mechanism for prioritizing improvement projects, while Lean Manufacturing can provide a rich toolbox of improvement techniques. The result – manufacturing effectiveness is significantly increased by eliminating waste from the parts of the system that are the largest constraints on opportunity and profitability.

While Lean Manufacturing tools and techniques are primarily applied to the constraint, they can also be applied to equipment that is subordinated to the constraint (e.g., to equipment that starves or blocks the constraint; to post-constraint equipment that causes quality losses).

The remainder of this section describes how to apply a range of Lean Manufacturing tools and techniques to the Five Focusing Steps.



The Five Focusing Steps of the Theory of Constraints can utilize established lean manufacturing tools as shown in the above diagram.

Applying Lean Tools to "Identify the Constraint"

Lean Manufacturing provides an excellent tool for visually mapping the flow of production (Value Stream Mapping) as well as a philosophy that promotes spending time on the plant floor (Gemba).

Lean Tool	Description
Value Stream Mapping	Value Stream Mapping (VSM) visually maps the flow of production (current and future states) using a defined set of symbols and techniques. • Provides a foundation from which to work when identifying the constraint. For example, the cycle time of each stage can be marked on the map. • Engages teams and useful for problem solving exercises. • Helpful for documenting complex processes.
Gemba	Gemba encourages leaving the office to spend time on the plant floor. This promotes a deep and thorough understanding of real-world manufacturing issues – by first-hand observation and by talking with plant floor employees. • Walking the plant floor, observing production, and interacting with employees can be a very effective way to gather information that helps identify the constraint.

Applying Lean Tools to "Exploit the Constraint"

Lean Manufacturing strongly supports the idea of making the most of what you have, which is also the underlying theme for exploiting the constraint. For example, lean teaches to organize the work area (5S), to motivate and empower employees (Visual Factory/Andon), to capture best practices (Standardized Work), and to brainstorm incremental ideas for improvement (Kaizen).

Lean Tool	Description
5S	5S is a program for eliminating the waste that results from a poorly organized work area. It consists of five elements: Sort (eliminate that which is not needed), Straighten (organize the remaining items), Shine (clean and inspect the area), Standardize (create standards for 5S), and Sustain (consistently apply the standards).

Lean Tool	Description
	• Creates a foundation for better performance at the constraint. • Enables faster identification of emerging issues at the constraint. • Results in increased motivation and pride (from the improved work environment).
Visual Factory / Andon	Visual Factory is a strategy for conveying information through easily seen plant floor visuals. Andons are visual displays that indicate production status and enable operators to bring immediate attention to problems – so they can be instantly addressed. • Displays constraint production metrics in real time – a powerful motivator. • Reduces reaction time to stoppages by instantly alerting operators to intervene. • Empowers operators to call immediate attention to problems at the constraint. • Increases focus by using visuals to reinforce the importance of the constraint.
Standardized Work	Standardized Work captures best practices in work area documents that are consistently applied by all operators and that are kept up-to-date with the current best practices. • Improves throughput by consistently applying best practices at the constraint. • Reduces variation by applying standardized procedures at the constraint. • Ensures that all operators setup and run the constraint in a repeatable way.
Kaizen	Kaizen provides a framework for employees to work in small groups that suggest and implement incremental improvements for the manufacturing process. It combines the collective talents of a company to create an engine for continuous improvement. • Provides a proven mechanism for generating ideas on how to exploit the constraint. • Identifies “quick win” opportunities for improving throughput of the constraint. • Engages operators to work as a team and to think critically about their work.

Applying Lean Tools to "Subordinate to the Constraint"

Lean Manufacturing techniques for regulating flow (Kanban) and synchronizing automated lines (Line Control) can be applied towards subordinating and synchronizing to the constraint.

Lean Tool	Description
Kanban	Kanban is a method for regulating the flow of materials, which provides for automatic replenishment through signal cards that indicate when more materials are needed. • Offers simple visual techniques for controlling the flow of materials. • Synchronizes material usage at the constraint with material usage in the upstream process by controlling when new materials are released into the process.
Line Control	Line Control is a sophisticated technique used with synchronous automated lines, such as FMCG (Fast Moving Consumer Goods) lines, which slaves non-constraint equipment to the constraint in such a way as to increase overall system throughput. • Provides an effective alternative to traditional Drum-Buffer-Rope for FMCG lines. • Optimizes constraint and non-constraint running speeds to maximize throughput and reduce the frequency of minor stops. • Reduces startup delays on the constraint by synchronizing equipment startup.

Applying Lean Tools to "Elevate the Constraint"

Lean Manufacturing techniques for proactively maintaining equipment (TPM), dramatically reducing changeover times (SMED), building defect detection and prevention into production processes (Poka-Yoke), and partially automating equipment (Jidoka) all have direct application when elevating the constraint. TPM and SMED can also be viewed as exploitation techniques (maximizing throughput using currently available resources); however, they are fairly complex and are likely to benefit from working with outside experts.

Lean Tool	Description
TPM	TPM (Total Productive Maintenance) offers a holistic approach to maintenance that focuses on proactive and preventative maintenance to maximize the operational time of the constraint (increasing up time, reducing cycle times, and eliminating defects).

Lean Tool	Description
	• Reduces the frequency of constraint breakdowns and minor stops. • Provides operators with a stronger feeling of "ownership" for their equipment. • Enables most maintenance to be planned and scheduled for non-production time. • Targets quality issues by finding and removing the root causes of defects.
SMED	SMED (Single-Minute Exchange of Die) is a method for dramatically reducing changeover time at the constraint. As many steps as possible are converted to external (performed while the process is running) and remaining steps are streamlined (e.g., bolts and manual adjustments are eliminated). • Increases usable production time at the constraint. • Enables smaller lot sizes, resulting in improved responsiveness to customer demand. • Enables smoother startups, since a simplified and standardized changeover process improves quality and consistency.
Poka-Yoke	Poka-Yoke (also referred to as "mistake proofing") designs defect detection and prevention into equipment with the goal of achieving zero defects. • Reduces the number of defects (which is also very important post-constraint). • Enables the operator to spend more time on Autonomous Maintenance.
Jidoka	Jidoka means "intelligent automation" or "automation with a human touch". It recognizes that partial automation is significantly less expensive than full automation. Jidoka also emphasizes automatic stoppage of equipment when defects are detected. • In some cases, the constraint cannot be broken without significant capital investment. Jidoka can provide valuable guidance on equipment design and upgrades.

BOTTLENECKS WITH THEORY OF CONSTRAINTS

Step 0: Define the Goal

Each system has a goal. What is it you want to achieve and how will you know when you've reached the goal? To determine the goal, need to understand who uses the output of the System

and what's valuable to them. After you understand that, find metrics to measure the throughput, or amount of value produced by the system.

Understanding the goal is often the most difficult step in the process. Finding the right goal and the right metrics to measure progress toward that goal will be critical to your success.

Step 1: Identify the Bottleneck

Each system has one constraint that determines the throughput of the entire system. The constraint can be a person, a team, a physical machine, one organizational rule, or anything else that limits the speed at which value flows through the system. The constraint is often called a bottleneck.

At its core, the Theory of Constraints provides an approach to finding the bottleneck and taking action to improve throughput of the system as a whole.

As mentioned earlier, making improvements anywhere but the bottleneck will not improve the throughput of the system and it can even have a negative effect.

How do you recognize a bottleneck? If the bottleneck is a person, team, department, or piece of equipment, work piles up in front of them and people downstream of the bottleneck are idle some of the time.

To help identify the bottleneck, you can use tools like flow charts, swim lane diagrams, root cause analysis, Pareto charts, or queuing models. Remember that a system can only have one constraint at a time.

It's important to understand that being a bottleneck doesn't mean a person or team is bad at what they do or that they're doing anything wrong. Being the bottleneck is neither good nor bad; it's just a fact of the system. There's always one constraint.

Now that we've identified the bottleneck, what can we do to improve throughput?

Step 2: Exploit the Bottleneck

The first way to try to address the bottleneck is to "exploit" it. Exploiting the bottleneck isn't what it sounds like. "Exploiting" means that we're ensuring that the bottleneck isn't distracted by non-throughput producing work.

If you think about it, the flow of value through the system is determined by a single constraint. Therefore, any work done by the bottleneck that doesn't contribute toward the goal is waste and results in less throughput.

You can exploit the bottleneck by ensuring that the bottleneck always works on the highest priority, highest value work that contributes to the goal. You can also:

- Make sure the bottleneck works on only one thing at a time. We want to get to done; stop starting and start finishing.
- Remove any non-throughput producing work from the bottleneck.
- Shield the bottleneck from interruptions and quickly remove impediments, but don't shield them from important information like customer input and feedback.
- Make sure that the bottleneck is never idle or waiting for information, equipment, or materials. This type of waste reduces the value producing work that the bottleneck can do.

You may want to use techniques such as brainstorming to identify possible experiments you can try to exploit the bottleneck and improve the system. After you implement the exploit experiment, measure the impact to see if it made a positive change.

Make sure you only change one thing at a time. If you make multiple changes, you can't tell if some changes had a positive effect and some had a negative effect.

After each change, you'll also want to go back to the beginning to make sure the goal hasn't changed. You'll also need to make sure that the bottleneck hasn't moved.

Through your improvements, it's quite possible that the original constraint is no longer the system constraint. You may have improved the bottleneck to a point where they're no longer the constraint and any additional improvements to the original bottleneck won't improve the system. That's why you go back to the first step after each change.

Start by exploiting the bottleneck because it requires the lowest investment. It only affects the single bottleneck and it doesn't require additional time or money, but results in higher throughput.

Step 3: Subordinate Decisions to the Bottleneck

After you've exhausted what you can do through exploiting the bottleneck, the next step is to subordinate decisions to the bottleneck. Subordinating decisions means the rest of the system works to help the bottleneck produce maximum value.

That's because people other than the bottleneck have some slack. If everyone is working toward the same goal, anyone working beyond the pace of the bottleneck is not increasing the throughput of the system.

Instead of working at what they do faster, they can work to the pace of the bottleneck and use their extra capacity to support the bottleneck.

Some approaches you can use are:

- Ensure that the work, information, and materials received by the bottleneck as an input to their work is of the highest quality.
- Have everyone work to the pace of the bottleneck (no faster or slower).

- Someone else may be able to take some non-specialized tasks from the bottleneck. At this stage, only have someone take on tasks if it doesn't require a large investment in time or money.

Subordinating decisions to the bottleneck is done after the exploit step because there's a slightly higher investment needed, but it's still relatively easy. Subordination only impacts a few resources and requires little investment.

As with the exploit step, find a subordination experiment, implement it, and measure the result. Afterwards, go back to the beginning. Has the goal changed? Has the bottleneck changed?

If not and after you exhausted what you can do to subordinate decisions to the bottleneck, the next step is to elevate the bottleneck.

Step 4: Elevate the Bottleneck

After doing what you can to exploit and subordinate, you can elevate the performance of the bottleneck. Elevating the bottleneck requires time and money, so it's done only after exploiting and subordinating.

You can elevate the bottleneck and improve performance by:

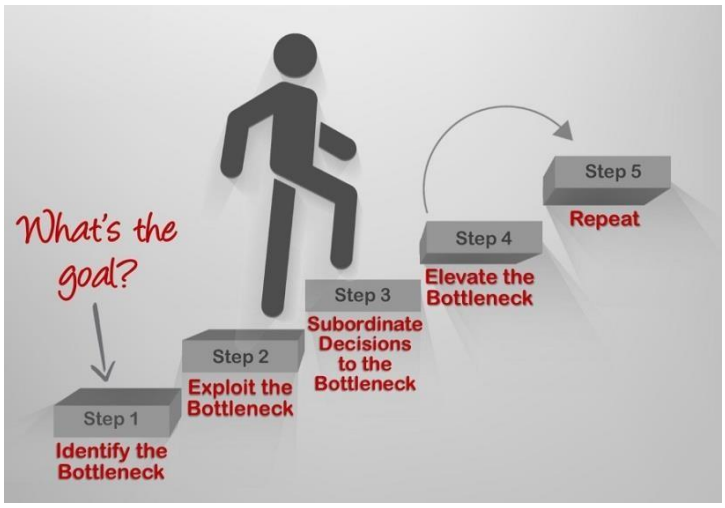
- Get more people that can do the same work as the bottleneck.
- Buy more or faster machines
- Give people training and better tools
- Coach for individual improvement
- Improve the workspace
- Change organizational policies

Often we jump right directly to elevating by adding people, getting training, buying equipment and tools. These changes can be expensive and it takes time to get a positive impact on throughput. They could even have a negative effect in the short term.

Elevate as a last resort when you can't find any more ways to exploit or subordinate.

Step 5: Repeat

Every time you find a potential improvement, implement it, measure the results and go back to the beginning. Make sure the goal is still valid and see if the constraint has moved.



The key is to see the system as a whole, understand what's valuable, and recognize the constraint. After that, make small changes one at a time starting with the easiest and cheapest to implement and measure the results.

UNIT IV

DEFINING QUALITY

The definition of quality depends on the point of view of the people defining it. Most consumers have a difficult time defining quality, but they know it when they see it. For example, although you probably have an opinion as to which manufacturer of athletic shoes provides the highest quality, it would probably be difficult for you to define your quality standard in precise terms. Also, your friends may have different opinions regarding which athletic shoes are of highest quality. The difficulty in defining quality exists regardless of product, and this is true for both manufacturing and service organizations. Think about how difficult it may be to define quality for products such as airline services, child day-care facilities, college classes, or even OM textbooks. Further complicating the issue is that the meaning of quality has changed over time.

Today, there is no single, universal definition of quality. Some people view quality as "performance to standards." Others view it as "meeting the customer's needs" or "satisfying the customer." Let's look at some of the more common definitions of quality.

THE QUALITY REVOLUTION

Many firms which attempted company-wide Total Quality (TQ) are achieving limited success, mediocre results, or nothing at all. Excited by glowing accounts of the achievements of Japanese companies, they've tried almost all the tricks and techniques straight from the books: organize Quality Control Circles (QCC), apply statistical quality control (SQC), exhort everybody with slogans on quality, and hire any guru who can talk about quality. To their disappointment, most employees are not responding and several managers are resisting the efforts. Typical reaction starts with elation and confusion, and ends with frustration. After several months of unexplained sham and shambles, the movement is aborted and life is back to normal: the company's defect rate is back at its normally high levels.

What many books and gurus on quality don't mention, intentionally or otherwise, is that the hardest part in implementing TQ is the changing of prevailing work attitudes and sentiments and not the application of techniques, statistical or organizational. For instance, they overlook the following attitudinal problems that hinder any quality improvement program:

- employees are not personally convinced of the importance of quality in their work; as long as they get their paychecks on time, nobody wants to rock the boat.- workers do not take management and its pronouncements seriously; - management distrusts workers, and regards them as mere hired hands incapable of thinking and coming out with bright ideas;

- nobody, employees and management alike, realize the need to change or improve simply because there is no crisis perceived; business can go on indefinitely with the status quo.

In short, the atmosphere is not usually conducive for introducing those quality techniques. How does a company seriously committed to adopt the Total Quality Culture (the real TQC) - and not just "total quality control"- start changing attitudes and molding a new culture for everybody? How does it begin overcoming the inertia of mediocre performance, shoddy products, and sloppy service that have been going on for decades? Before forming those quality circles and posting those charts and slogans, some groundwork or agitation have to be done to create the proper atmosphere - so that all employees would get the message that the company means business, that the "more of the same" lifestyle is out of style, and that quality is a must, not a motto. The following suggestions are not necessarily complete nor in the right order, but they should give an idea on how to incite the quality "revolution".

Let customers confront your employees

If a customer is furious at the company for a defective product he purchased, let him unleash some of that fury directly at the employee(s) responsible for the sloppy job. By stunning the latter, the same mistake would seldom be repeated. Conversely, if your customer has high praises for a job well done, don't take all the credit; reserve some or all for the responsible employees. In short, create every opportunity for your employees to receive direct feedback from your customers regarding the quality of their work. Many workers have been so used to their boss' so-so management style for years, that they take any sudden exhortation about quality from him with suspicion. Employees take more seriously responses from customers who pay for and use the company's products.

Japan Airlines (JAL) shows us a good example on how customers and employees can be made to stick together to achieve quality excellence. After the tragic JAL 747 crash in 1985, in order to regain the confidence of the riding public, the management directed that each aircraft shall have a dedicated maintenance crew personally responsible for the safety of its passengers and assigned aircraft. The names of the crew members shall be permanently posted on a plaque inside the plane for all passengers to see upon boarding. Moreover, (and this is the clincher), after every major overhaul and repair of its aircraft, the maintenance crew shall take its first flight with the passengers regardless of destination -- truly one of the most effective quality assurance (QA) measures I've encountered.

Dismantle all rework and recycling operations

"Do it right the first time," so goes the saying, and quality will improve. Very true -- but unfortunately, there are rework, repair, recycling operations and operators proliferating in many companies that tempt workers to do it wrong the first time (and succeeding times) because they see people who are paid to undo their mistakes. Immediately remove these temptations and realize that it is better to pile up defects in front of the worker for everyone to see rather than stash them in the rework lines. In this way, the problem surfaces and the company is forced to attack its root and origin, rather than depend on stopgap measures. Companies with rework operations usually notice that they multiply and create a vicious cycle: rework lines encourage more defects, more rework, and more lines. The danger is that these lines are very deceiving and barely noticeable from afar: they look like regular lines using the same machines, the same people.

Rework is most common in the plastic industry where one executive boasted that his company always achieves zero defect and no wastes, in spite of the shop floor being cluttered with them. His confidently argues that no plastic raw material is really thrown away since his "defects" can be remelted and remolded indefinitely. He fails to consider the labor, overhead, and opportunity lost every time he recycles. Inside one large car manufacturer I visited in Canada, the tour guide was bragging that his company has been applying Total Quality and Just-in-Time principles. As expected, the plant was almost fully automated, with scores of robots mostly doing welding operations. Very impressive -- until we reached the end of the production line that snakes inside the factory. I finally saw people - a dozen workers busily welding. I inquired why their work have not been automated since the robots were doing the same thing. He explained that these last operations cannot be automated since the human workers were rewelding what the robots missed in the earlier stages. So instead of fixing the robots, the company decided to provide employment.

Deliberately reduce all inventories

Inventories are ideal places to hide defects, obsolete products, and bad planning decisions. Like rework lines, reduce or eliminate these hideouts to flush out the problems and wastage. Avoid the overproduction, oversupplying, and overbuying of anything. Reduce to a minimum all sorts of inventories and supplies: raw materials, in-process, finished goods, and yes, paper clips and computer paper too. It is human nature to squander or fumble with anything in abundance; it is also human nature to cherish and economize anything in scarcity. By reducing inventories, the production flow becomes smoother and clearer; defects are easily spotted and solved. Workers would tend to be more careful in handling and processing materials, since there would be much less replacements and substitutes on hand.

Start and do everything on time

Quality is about following standards. The best way to develop and exercise this habit of following standards among all employees and managers is to start enforcing the most universal, the most explicit, and the most frequently violated standard in the company: time. Start and finish meetings on time. Don't wait for latecomers regardless of rank, nor brief them on what they've missed. End meetings on time even without conclusions or reaching the last item in the agenda. In many Japanese companies, meeting rooms are maintained either too cold or too hot to make the occupants very uncomfortable if they stay too long dabbling with idle talk and pointless discussions. In one company I've seen, somebody has to turn on the lights every 30 minutes; each meeting room has tamper proof timers set to irritate everybody and regularly remind those inside the room the company time and electrical energy they've used (or wasted).

Start and finish schedules and programs on time. In a company's QC circle competition where I was invited as guest speaker, the program started late by 45 minutes because the presentors, the president, and even the judges arrived late. The irony and sham are commonplace: people preaching and professing quality, without practicing it. In my speech I told them that if I were a customer, I would not have waited for them and simply walk out, and there goes your account.

Make it an unbending policy to deliver your goods on time, no matter what it takes. McDonalds trains its counter personnel in its Hamburger University to serve an order of a hamburger, a milk shake, and french fries in 50 seconds or less. Domino, one of the biggest pizza chain in the U.S., promises to deliver its freshly-made pizza at your doorstep within 30 minutes or it will knock off $3 from the price. Institute penalties, if none exist, for non-compliance with schedules and let everybody realize that there is a price to pay for not following time standards in dealing with co-employees or customers.

Clean up the work environment

Cleanliness is not only next to godliness, it is also next to quality. In evaluating Japanese companies for the much-coveted Deming Prize for Quality, the stern and meticulous judges, prior to checking product and process quality, start by inspecting the toilets, canteen, locker rooms, and floors -- usually the untidiest places inside any company. The principle is simple and almost infallible: workers cannot concentrate in producing quality products inside a dirty environment. They also check the racks, desks, stockrooms and check if things are in order and in the right places. Again the same principle: if what you see in front of you is cluttered, your mind tends to be cluttered too, and cluttered minds cannot think about anything, much less about quality. In most Deming prize awardees, the shop floors are so clean you can literally sleep on them. Cleanliness and orderliness are cardinal virtues in a true quality culture. They should become habits of all employees and managers. Prepare the mind first, and begin discussing total quality with your employees only after you have created a clean and orderly work environment.

Export or sell to more quality-conscious markets

Companies in the export business tend to improve their product quality faster that those just catering to the local market. The reason is simple: as far as their customers are concerned - the importers usually thousands of miles away - quality is non-negotiable. Non-compliance or late deliveries are punished with stiff penalties, non-payment, or contract termination. But domestic buyers will usually accept shoddy products provided the prices are low. Having more sense of humor than the overseas importers, they are more accessible and more open to compromises and free lunches to soothe quality complaints. Moreover, the domestic markets and consumers in many Asian countries are less fussy about quality. Many domestic sellers, often spoilt by their own customers, just grow old but never grow up in terms of quality.

Japanese companies were able develop high-quality goods in a short period of time simply because they export a substantial amount, usually 50%, of their production. In most countries, the airline industry, actually an export business, is the most strict and meticulous about quality and reliability because it has to deal with international passengers, competitors, and standards. According to one Japanese executive, the ultimate quality challenge for any foreign garment exporter is to succeed in selling to the Japanese - which he describes as the only nationality that looks under the skirt before deciding to buy it. It is interesting to note that some local products are marked "export quality" or even "export overruns" just to suggest good quality to the customers. By venturing into the export business, a company is challenged to satisfy very discriminating markets and compete internationally. Under this "sink-or-swim though quality"

situation, its management and employees will realize the urgent need to improve quality to a much higher level than before.

Conclusion

Achieving TQ usually means a revolution, a 180-degree change in corporate culture, and the throwing away of many ingrained thinking and working habits by workers and managers alike. It requires the precision, patience, and power to steer an oil tanker or aircraft carrier into the opposite direction. Attaining 99.9997% quality level demands a very strong leadership with a very strong corporate will, making hard decisions and supreme sacrifices. As such, TQ is not for everybody. Negative thinkers and companies with weak convictions and commitments need not try TQ, for failure is guaranteed.

CONCEPT AND PHILOSOPHY OF TOTAL QUALITY MANAGEMENTS

INTRODUCTION

In the present competitive environment, survival of the organizations depends on their ability to continuously improve as per the expectations of the customers. Quality is critical in achieving competitiveness in domestic and global market.

Though there are wide variety of concepts surrounding the term "quality", all writers agree that quality is one of the important "critical success factors" to achieve competitiveness in organizations. Quality has expanded beyond the concept of "customer satisfaction with products and services" to the concept of "creation of worth for all stakeholders".

In this context, overall business excellence is replacing the narrow objective of meeting customer specifications to improving the performance of the whole system. This includes array of issues, including environment, occupational health and safety, and social responsibility.

The success of TQM mainly depends on the achievement of internal as well as external customer satisfaction. Internal customer satisfaction is a prerequisite to achieve external customer satisfaction.

Quality is a journey starting from design, to conformance, and ends at better performance. This process considers quality as a 'never ending' improvement (Gitlow, 1989).

Quality of design → conformance → performance

a. Quality of design: This is the degree of achievement of purpose by the design itself. It starts with market research, sales feedback analysis and continues the development of a product/service that would satisfy the customer.

b. Quality of conformance: It is the extent to which a firm, its processes and its suppliers are able to surpass the design specifications required to serve the needs of the customer.

c. Quality of performance: This identifies the extent to which customer needs are satisfied by performance of a product/service over a period of time.[6]

Total - The responsibility for achieving Quality rests with everyone a business no matter what their function. It recognises the necessity to develop processes across the business, that together lead to the reliable delivery of exact, agreed customer requirements. This will achieve the most competitive cost position and a higher return on investment.

Quality - The prime task of any business is to understand the needs of the customer, then deliver the product or service at the agreed time, place and price, on every occasion. This will retain current customers, assist in acquiring new ones and lead to a subsequent increase in market share.

Management - Top management lead the drive to achieve quality for customers, by communicating the business vision and values to all employees; ensuring the right business processes are in place; introducing and maintaining a continuous improvement culture. To gain an understanding of TQM, it is worth looking at how it developed and the impact of some of the main management "gurus" over the years.[3]

2. DEFINiTION OF TOTAL QUALITY MANAGEMENT

Total quality management is a business philosophy that seeks to encourage both individual and collective responsibility to quality at every stage of the production process from initial design and conception through to after sales services.

TQM is a management philosophy, a paradigm, a continuous improvement approach to doing business through a new management model. The TQM philosophy evolved from the continuous improvement philosophy with a focus on *quality* as the main dimension of business.

TQM is a comprehensive management system which:
♦ Focuses on meeting owners'/customers' needs by providing quality services at a cost that provides value to the owners/customers
♦ Is driven by the quest for continuous improvement in all operations
♦ Recognizes that everyone in the organization has owners/customers who are either internal or external
♦ Views an organization as an internal system with a common aim rather than as individual departments acting to maximize their own performances
♦ Focuses on the *way* tasks are accomplished rather than simply *what* tasks are accomplished
♦ Emphasizes teamwork and a high level of participation by all employees.

3. CONCEPTS FROM QUALITY GURUS

(a) Deming's approach.

Deming had made a highly significant contribution during the war in increasing America's industrial efficiency.

After the war was won, although well received by engineers and scientists, top management did not respond to his ideas. Industry went back to the old established ways of trying to meet consumer market opportunities.

In Japan however Deming found a much more receptive audience, his ideas once implemented led during the 80s, to American business being battered by Japan's superior industrial practices.

In order to compete and survive, the rest of the world were forced to take his ideas seriously, adopting "Japanese methods" such as TQM and Lean Manufacturing.

Deming proposed 14 points as the principles of TQM (Deming, 1986), which are listed below:

PRINCIPLE 1: "Create a constancy of purpose"
· Define the problems of today and the future
· Allocate resources for long-term planning
· Allocate resources for research and education
· Constantly improve design of product and service

PRINCIPLE 2: "Adopt the new philosophy"
· Quality costs less not more
· Superstitious learning
· The call for major change
· Stop looking at your competition and look at your customer instead

PRINCIPLE 3: "Cease dependence on inspection"
· Quality does not come from inspection
· Mass inspection is unreliable, costly, and ineffective
· Inspectors fail to agree with each other
· Inspection should be used to collect data for process control

PRINCIPLE 4: "Do not award business basedon price tag alone"
· Price alone has no meaning
· Change focus from lowest initial cost to lowest total cost
· Work toward a single source and long term relationship
· Establish a mutual confidence and aid between purchaser and vendor

PRINCIPLE 5 : "Improve constantly the system of production and service"
· Quality starts with the intent of management
· Teamwork in design is fundamental
· Forever, continue to reduce waste and continue to improve
· Putting out fires is not improvement of the process

PRINCIPLE 6 : "Institute training"
· Management must provide the setting where workers can be successful
· Management must remove the inhibitors to good work

- Management needs an appreciation of variation
- *This is management's new role.*

PRINCIPLE 7: "Adopt and institute leadership"
- MBO's
- Work standards
- Meet specifications
- Zero defects
- Appraisal of performance
- *Replace with leadership*

Leaders must:
- Remove barriers to pride of workmanship
- Know the work they supervise
- Know the difference between special and common cause of variation

PRINCIPLE 8 : "Drive out fear"
- The common denominator of fear
- The fear of knowledge
- Performance appraisals
- Management by fear or numbers

PRINCIPLE 9: "Break barriers among staff areas"
- Know your internal suppliers and customers
- Promote team work

PRINCIPLE 10: "Eliminate slogans, exhortations,and targets
- They are directed at the wrong group
- They generate frustration and resentment
- Use posters that explain what management is doing to improve the work environment

PRINCIPLE 11:"Eliminate numerical quotas"
- They impede quality
- They reduce production
- A person's job becomes meeting a quota

PRINCIPLE 12 : "Remove barriers"
- Performance appraisal systems
- Production rates
- Financial management systems
- Allow people to take pride in their workmanship

PRINCIPLE 13:"Institute a program of education and self-improvement"
- Commitment to lifelong employment
- Overtime and education

· Work with higher education of needs
· Develop team building skills in children

PRINCIPLE 14: "Take action to accomplish the transformation" Management must:
· Struggle over the fourteen points
· Take pride in the new philosophy
· Include the critical mass of people in the change
· Learn and use the Shewhart cycle[2]

(b) Juran's approach :

Juran believed that main quality problems are due to management rather than workers. The attainment of quality requires activities in all functions of a firm. Firm-wide assessment of quality, supplier quality management, using statistical methods, quality information system, and competitive benchmarking are essential to quality improvement. Juran's approach is emphasis on team (QC circles and self-managing teams) and project work, which can promote quality improvement, improve communication between management and employees coordination, and improve coordination between employees.

According to Juran, it is very important to understand customer needs. Identifying customer needs requires more vigorous analysis and understanding to ensure the product meets customers' needs and is fit for its intended use, not just meeting product specifications. Thus, market research is essential for identifying customers' needs.

Juran considered quality management as three basic processes (Juran Trilogy): Quality control, quality improvement, and quality planning.

Juran defined four broad categories of quality costs, which can be used to evaluate the firm's costs related to quality. Such information is valuable to quality improvement. The four quality costs are listed as follows:
- Internal failure costs (scrap, rework, failure analysis, etc.), associated with defects found prior to transfer of the product to the customer;

- External failure costs (warranty charges, complaint adjustment, returned material, allowances, etc.), associated with defects found after product is shipped to the customer;

- Appraisal costs (incoming, in-process, and final inspection and testing, product quality audits, maintaining accuracy of testing equipment, etc.), incurred in determining the degree of conformance to quality requirements;

- Prevention costs (quality planning, new product review, quality audits, supplier quality evaluation, training, etc.), incurred in keeping failure and appraisal costs to a minimum.[2]

(c).Crosby's Approach:

Crosby (1979) identified a number of important principles and practices for a successful quality improvement program, which include, for example, management participation, management responsibility for quality, employee recognition, education, reduction of the cost of quality (prevention costs, appraisal costs, and failure costs), emphasis on prevention rather than after-the-event inspection, doing things right the first time, and zero defects.

Crosby offered a 14-step program that can guide firms in pursuing quality improvement. These steps are listed as follows:

(1) Management commitment: To make it clear where management stands on quality.

(2) Quality improvement team: To run the quality improvement program.

(3) Quality measurement: To provide a display of current and potential nonconformance problems in a manner that permits objective evaluation and corrective action.

(4) Cost of quality: To define the ingredients of the cost of quality, and explain its use as a management tool.
(5) Quality awareness: To provide a method of raising the personal concern felt by all personnel in the company toward the conformance of the product or service and the quality reputation of the company.
(6) Corrective action: To provide a systematic method of resolving forever the problems that are identical through previous action steps.
(7) Zero defects planning: To investigate the various activities that must be conducted in preparation for formally launching the Zero Defects program.
(8) Supervisor training: To define the type of training that supervisors need in order to actively carry out their part of the quality improvement program.
(9) Zero defects day: To create an event that will make all employees realize, through a personal experience, that there has been a change.
(10) Goal setting: To turn pledges and commitment into actions by encouraging individuals to establish improvement goals for themselves and their groups.
(11) Error causal removal: To give the individual employee a method of communicating to management the situation that makes it difficult for the employee to meet the pledge to improve.
(12) Recognition: To appreciate those who participate.
(13) Quality councils: To bring together the professional quality people for planned communication on a regular basis.
(14) Do it over again: To emphasize that the quality improvement program never ends.[2]

(d). Ishikawa's Approach:
Ishikawa6 (1985) argued that quality management extends beyond the product and encompasses after-sales service, the quality of management, the quality of individuals and the firm itself. He claimed that the success of a firm is highly dependent on treating quality improvement as a never-ending quest. A commitment to continuous improvement can ensure that people will never stop learning. He advocated employee participation as the key to the successful implementation of TQM. Quality circles, he believed, are an important vehicle to achieve this. Like all other gurus he emphasized the importance of education, stating that quality begins and ends with it. He

has been associated with the development and advocacy of universal education in the seven QC tools (Ishikawa, 1985). These tools are listed below:
- Pareto chart;
- Cause and effect diagram (Ishikawa diagram);
- Stratification chart;
- Scatter diagram;
- Check sheet;
- Histogram;
-Control chart.
Ishikawa's concept of TQM contains the following six fundamental principles:
- Quality first-not short-term profits first;
- Customer orientation-not producer orientation;
- The next step is your customer-breaking down the barrier of sectionalism;
- Using facts and data to make presentations-utilization of statistical methods;
- Respect for humanity as a management philosophy, full participatory management;
- Cross-functional management.[2]

4. ELEMENTS OF T.Q.M.

These elements can be divided into four groups according to their function.
Foundation – it includes: ethics, integrity and trust.
Building bricks – it includes: Training, teamwork and leadership.
Binding mortar – it includes: communication.
Roof – it includes recognition

TQM has been coined to describe a philosophy that makes quality the driving force behind Leadership, design, planning, and improvement initiatives.

I. Foundation

1. Ethics
Ethics is discipline concerned with good and bad in any situation. It is two faceted subject represented by organization and individual ethics.

Organization ethics establish a business code of ethics that outlines guidelines that all employees are to adhere to in the performance of their work.

Individual ethics include personal rights or wrongs.

2. Integrity
Integrity implies honest , morals, values, fairness, and adherence to the fact and sincerity. The characteristics is what customer (internal or external) expect and deserve to receive. Peoples see the opposite of integrity as duplicity. TQM will not work in an atmosphere of duplicity.

3. Trust
Trust is by- products of integrity and ethical conduct. Without trust , the framework of TQM can

not be built. Trust forester full participation of all members. It allows empowerment that encourage pride ownership and it encourage commitment.[4]

II. Bricks

Basing on the strong foundation of the trust, ethics and integrity, bricks are placed to reach the roof of recognition it includes;

4. Training

Training is very important for employees to be highly productive. Supervisors are solely responsible for implementing TQM within their departments and teaching their employee and philosophy of TQM.

Training that employees require are interpersonal skills, the ability to fuction within terns problem solving, decision making, job management, performance analysis and improvement, business economics and technical skills.

5. Teamwork

To become successful in the business, teamwork is also key element of TQM. With the use of teams, the business will receive quicker and better solution to problems. Teams also provide more permanent improvement in processes and operations.

There are mainly three type of teams that TQM organization adopt:

A. Quality improvement teams or excellence teams (QITS)

These are temporary team with the purpose of dealing with specific problems that often re-occur. These team are set up for period of three to twelve months.

B. Problem solving teams (PST)

These are teamporary teams to solve certain problems and also to identity and overcome cause of problems. They generally last from one week to three months.

C. Natural work teams (NWT)

These teams consists of small groups of skilled workers who share task and responsibilities. These use concept such as employee involvement teams, self-managing teams and circles. these teams generally works for one to two hours a week.

6. Leadership

It is possibly the most important element in TQM. It appears everywhere in an organization. Leadership in TQM requires the manager to provide an inspiring vision, make strategic direction that are understood by all and to instill value that guide subordinates.

For TQM to be successful in the business, the supervisor must be committed in leading his employees. A supervisor must understand TQM, believe in it and then demonstrate their believe and commitment through their daily practices of TQM.[4]

III. Binding mortar

7. Communication
It binds everything together. Starting from to roof the TQM house, everything is bound by strong mortar of communication. It acts as a vital linkbetween all elements of TQM. Communication means a common understanding of ideas between the sender and the receiver.

The success of TQM demands communication with and among all the organization members, supplier and customers. Supervisor must keep open airway where employee can send and receive information about the TQM process.

There are different ways of communication such as:
A. Downward communication – this is dominants form of communication in an organization. Presentation and discussion basically do it. By this the supervisor are able to make the employees clear about TQM.

B. Upward communication – by this lower level of employees are to provide suggestion to upper management of the effects of TQM. As employees provide insight and constructive criticism, supervisors must listen effectively to correct the situation that comes about through the use of TQM. This forms a level of trust between supervisors and employees.

C. Sideways communication – this type of communication is important because it breaks down barrier between departments. It also allows dealing with customers and suppliers in a more professional manner.[4]

8. Recognization –
It is the lastand final element in the entire system it shoud be provided for both suggestions and achievements for teams as well as individuals. Employees strive to receive recognition for themselves and their teams.

Detecting and recognizing contributors is the most important job a supervisor. As people are recognized, there can be huge changes in self-esteem, productivity , quality and the amount if effort exhorted to the task at hand. Recognition comes in its form when it is immediately following an action that an employee has performed.

Recognition comes in different ways, places and time such as, ways-
It can be by way of personal letter from top management.

Also by award banquets, plaques, trophies etc.

Places- good performers can be recognized in front of departments, on performance boards and also in front of top management.

Time - recognition given at any time like in staff meeting, annual award banquets, etc.

We can conclude that these eight elements are key in ensuring the success of TQM.

In an organization and that the supervisor is a huge part in developing these elements in the work place. without these elements, the business entities can not be successful TQM implementers.

It is very clear from the above that TQM without involving integrity, ethics and trust would be great remiss, in fact it would be incomplete.

Training is the key by which the organization creates a TQM environment.

Leadership and teamwork go hand in hand.

Lack of communication between departments, supervisors and employees create a burden on the whole TQM process.

Last but not least, recognition should be given to people who contributed to the overall completed task.

Hence, lead by example, train employees to provide a quality product, creats an environment where there is no fear to share knowledge, and credit where credit is due.

The primary elements in the Deming Application Prize and the checklist used to evaluate senior executives are listed below:

(1) Policies
- Quality and quality control policies and their place in overall business management;
- Clarity of policies (targets and priority measures);
- Methods and processes for establishing policies;
- Relationship of policies to long- and short-term plans;
- Communication (deployment) of policies, and grasp and management of achieving policies;
- Executives' and managers' leadership.

(2) Organization
- Appropriateness of the organizational structure for quality control and status of employee involvement;
- Clarity of authority and responsibility;
- Status of interdepartmental coordination;
- Status of committee and project team activities;
- Status of staff activities;
- Relationships with associated companies (group companies, vendors, contractors, sales companies, etc.).

(3) Information
- Appropriateness of collecting and communicating external information;
- Appropriateness of collecting and communicating internal information;
- Status of applying statistical techniques to data analysis;
- Appropriateness of information retention;

- Status of utilizing information;
- Status of utilizing computers for data processing.

(4) Standardization
- Appropriateness of the system of standards;
- Procedures for establishing, revising and abolishing standards;
- Actual performance in establishing, revising and abolishing standards;
- Contents of standards;
- Status of utilizing and adhering to standards;
- Status of systematically developing, accumulating, handing down and utilizing technologies.

(5) Human resources
- Education and training plans and their development and results utilization;
- Status of quality consciousness, consciousness of managing jobs, and understanding of quality control;
- Status of supporting and motivating self-development and self-realization;
- Status of understanding and utilizing statistical concepts and methods;
- Status of QC circle development and improvement suggestions;
- Status of supporting the development of human resources in associated companies.

(6) Quality assurance
- Status of managing the quality assurance activities system;
- Status of quality control diagnosis;
- Status of new product and technology development (including quality analysis, quality deployment and design review activities);
- Status of process control;
- Status of process analysis and process improvement (including process capability studies);
- Status of inspection, quality evaluation and quality audit;
- Status of managing production equipment, measuring instruments and vendors;
- Status of packaging, storage, transportation, sales and service activities;
- Grasping and responding to product usage, disposal, recovery and recycling;
- Status of quality assurance;
- Grasping of the status of customer satisfaction;
- Status of assuring reliability, safety, product liability and environmental protection.

(7) Maintenance
- Rotation of management (PDCA) cycle control activities;
- Methods for determining control items and their levels;
- In-control situations (status of utilizing control charts and other tools);
- Status of taking temporary and permanent measures;
- Status of operating management systems for cost, quantity, delivery, etc.;
- Relationship of quality assurance system to other operating management systems.

(8) Improvement
- Methods of selecting themes (important activities, problems and priority issues);
- Linkage of analytical methods and intrinsic technology;

- Status of utilizing statistical methods for analysis;
- Utilization of analysis results;
- Status of confirming improvement results and transferring them to maintenance/control activities;
- Contribution of QC circle activities.

(9) Effects
- Tangible effects (such as quality, delivery, cost, profit, safety and environment);
- Intangible effects;
- Methods for measuring and grasping effects;
- Customer satisfaction and employee satisfaction;
- Influence on associated companies;
- Influence on local and international communities.

(l0) Future plans
- Status of grasping current situations;
- Future plans for improving problems;
- Projection of changes in social environment and customer requirements and future plans based on these projected changes;
- Relationships among management philosophy, vision and long-term plans;
- Continuity of quality control activities;
- Concreteness of future plans.[4]

5. THE PHILOSOPHY OF TQM

What characterizes TQM is the focus on identifying root causes of quality problems and correcting them at the source, as opposed to inspecting the product after it has been made. Not only does TQM encompass the entire organization, but it stresses that quality is customer driven.

(a) quality circle

Some organisations have successfully implemented the use of quality circles as part of an ongoing improvement programme. Others have experimented with quality circles with the best intentions and faced several obstacles, but what is true is that this type of participatory management brings several benefits to all concerned.

Objectives:
1. TO improve the quality and productivity and thus contribute to the improvements and development of the enterprise.
2. To reduce the cost of products or services by waste reduction, safety, effective utilization of resources, avoiding unnecessary errors and defects.
3. To identify and solve work related problems that interferes with production.
4. To tap the creative intelligence of the persons working in the organization and to make full use of the human resources.
5. To permit employees to develop and use greater amount of knowledge and skill and motivate them to apply to a wide range of challenging tasks.
6. To improve communication within the organization.

7. To increase employees loyalty and commitment to the organization and its goals.
8. To respect humanity and build a happy bright work place environment which is meaningful to work in.
9. To enrich human capability, confidence, moral, attitude and relationship.
10. To safety the human needs of recognition , achievement and self-development.

Advantage:
1. Promote high level of productivity and quality-mindedness.
2. Self and mutual development of employees.
3. Creating team spirit and unity of action.
4. Increased motivation, job satisfaction and pride in their work.
5. Reduced absenteeism and labour turnover.
6. Developing sense of belongingness towards a particular organization.
7. Waste reduction.
8. Cost reduction.
9. Improved communication.
10. Safety improvement.
11. Increase utilization of human resource potential.
12. Enhancement in consciousness and moral of employees through re cognition of their activities.
13. Leadership development.
14. Trained staff.[7]

FUNCTION OF QUALITY CIRCLE:

Quality circles are also commonly known as work improvement or quality teams, but no matter the name, their functions share similar characteristics. Generally, the quality circle is a small group of employees who voluntarily meet at regular times to identify, analyse and solve quality and other problems in their working environment. Quality circles can recommend and implement improvement strategies and be a useful reservoir for the generation of new ideas.[7]

Internal Reform Committees (IRC's):
Internal Reform Committees (IRC's) are the public service's tailor-made answer to quality circles. IRC's were introduced into the public service to encourage full employee participation in home-grown reform initiatives to meet the needs of the public service.

The main objectives were to:
*?Encourage a team culture and team environment;
*?Encourage the flow of new ideas;
*?Improve customer relations and service delivery;
*?Improve levels of communication;
*?Improve operational efficiency; and
*?Create problem prevention attitudes.[7]

(b)Customer Focus

The first, and overriding, feature of TQM is the company's focus on its customers.

Quality is defined as meeting or exceeding customer expectations. The goal is to first identify and then meet customer needs. TQM recognizes that a perfectly produced product has little value if it is not what the customer wants. Therefore, we can say that quality is *customer driven.* However, it is not always easy to determine what the customer wants, because tastes and preferences change. Also, customer expectations often vary from one customer to the next.

There exists in each department, each office, each home, a series of customers, suppliers and customer supplier interfaces. These are "the quality chains", and they can be broken at any point by one person or one piece of equipment not meeting the requirements of the customer, internal or external. The failure usually finds its way to the interface between the organisation and its external customer, or in the worst case, actually to the external customer.

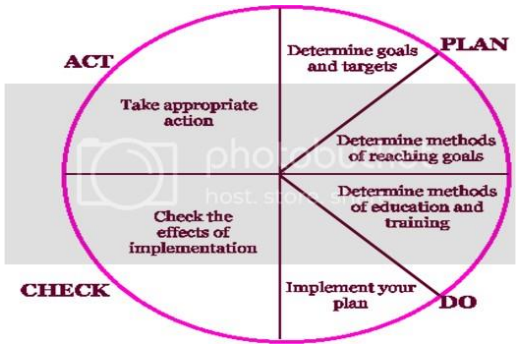
(c) Continuous Improvement

Another concept of the TQM philosophy is the focus on continuous improvement. raditional systems operated on the assumption that once a company achieved a certain level of quality, it was successful and needed no further improvements.

Continuous improvement, called kaizen by the Japanese, requires that the company continually strive to be better through learning and problem solving. Because we can never achieve perfection, we must always evaluate our performance and take measures to improve it. Now let's look at two approaches that can help companies with continuous improvement: the plan –do– study – act (PDSA) cycle and benchmarking.[5,1]

I THE PLAN–DO–STUDY–ACT CYCLE:

The plan–do–study–act (PDSA) cycle describes the activities a company needs to perform in order to incorporate continuous improvement in its operation.



• ***Plan***The first step in the PDSA cycle is to *plan*. Managers must evaluate the current process and make plans based on any problems they find. They need to document all current procedures, collect data, and identify problems. This information should then be studied and used to develop a plan for improvement as well as specific measures to evaluate performance.

• ***Do***The next step in the cycle is implementing the plan (*do*). During the implementation process managers should document all changes made and collect data for evaluation.

• ***Study*** The third step is to *study* the data collected in the previous phase. The data are evaluated to see whether the plan is achieving the goals established in the *plan* phase.

• ***Act***The last phase of the cycle is to *act* on the basis of the results of the first three phases. The best way to accomplish this is to communicate the results to other members in the company and then implement the new procedure if it has been successful. Note that this is a cycle; the next step is to plan again. After we have acted, we need to continue evaluating the process, planning, and repeating the cycle again.[1,5]

II. ***BENCHMARKING***

SimplyBenchmarking Studying the businesspractices of other companies for purposes of comparison.

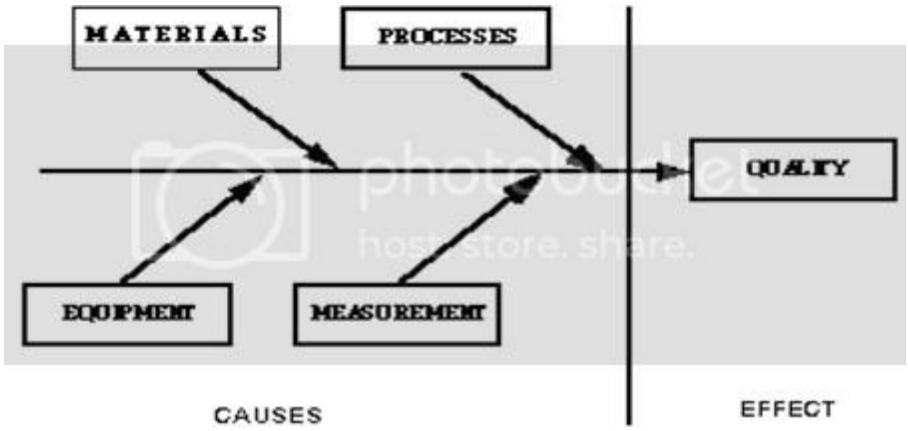
Another way companies implement continuous improvement is by studying business practices of companies considered "best in class." This is called benchmarking. The ability to learn and study how others do things is an important part of continuous improvement. The benchmark company does not have to be in the same business, as long as it excels at something that the company doing the study wishes to emulate.

(d). Quality tools:

You can see that TQM places a great deal of responsibility on all workers. If employees are to identify and correct quality problems, they need proper training. They need to understand how to assess quality by using a variety of quality control tools, how to interpret findings, and how to correct problems. In this section we look at seven different quality tools. These are often called the seven tools of quality control. [1]

i. *Cause-and-Effect Diagrams*

Cause-and-effect diagrams are charts that identifypotential causes for particular quality problems. They are often called fishbone diagrams because they look like the bones of a fish.



The "head" of the fish is the quality problem, such as damaged zippers on a garment or broken valves on a tire. The diagram is drawn so that the "spine" of the fish connects the "head" to the possible cause of the problem. These causes could be related to the machines, workers, measure ment, suppliers, materials, and many other aspects of the production process.

Cause-and-effect diagrams are problem-solving tools commonly used by quality control teams. Specific causes of problems can be explored through brainstorming. The development of a cause-and-effect diagram requires the team to think through all the possible causes of poor quality.

ii. Flowcharts

A flowchart is a schematic diagram of the sequence of steps involved in an operation or process. It provides a visual tool that is easy to use and understand. By seeing the steps involved in an operation or process, everyone develops a clear picture of how the operation works and where problems could arise.

iii. Checklists

A checklistis a list of common defects and the number of observed occurrences of these defects. It is a simple yet effective fact-finding tool that allows the worker to collect specific information regarding the defects observed.

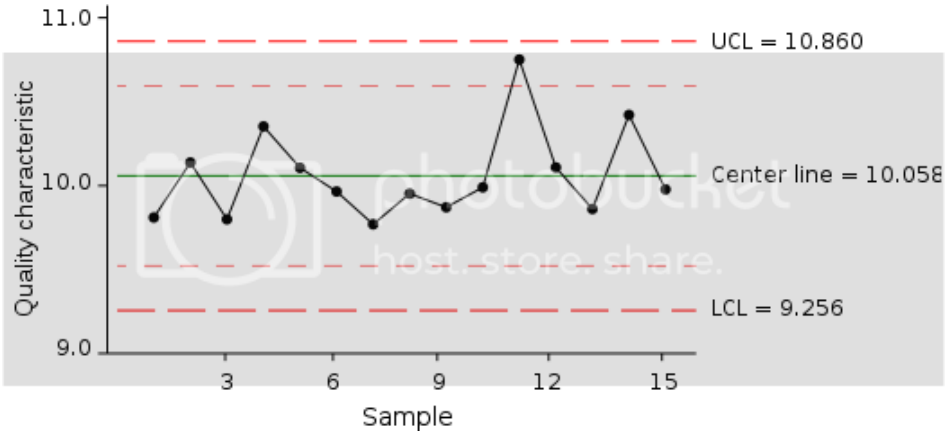
if a defect is being observed frequently, a checklist can be developed that measures the number of occurrences per shift, per machine, or per operator. In this fashion we can isolate the location of the particular defect and then focus on correcting the problem.[1]

iv. Control Charts

Control charts are a very important quality control tool. These charts are used to evaluate whether a process is operating within expectations relative to some measured value such as weight, width, or volume. For example, we could measure the weight of a sack of flour, the

width of a tire, or the volume of a bottle of soft drink. When the production process is operating within expectations, we say that it is "in control."

To evaluate whether or not a process is in control, we regularly measure the variable of interest and plot it on a control chart. The chart has a line down the center representing the average value of the variable we are measuring. Above and below the center line are two lines, called the upper control limit (UCL) and the lower control limit (LCL). As long as the observed values fall within the upper and lower control limits, the process is in control and there is no problem with quality. When a measured observation falls outside of these limits, there is a problem.



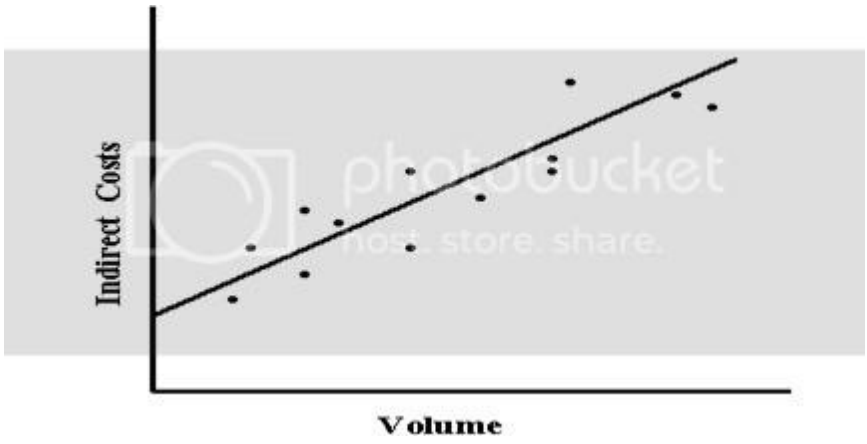
v. ***Scatter Diagrams*** **Scatter diagrams** are graphs that show how two variables are related to one another. They are particularly useful in detecting the amount of correlation, or the degree of linear relationship, between two variables.

The greater the degree of correlation, the more linear are the observations in the scatter diagram. On the other hand, the more scattered the observations in the diagram, the less correlation exists between the variables.[1]

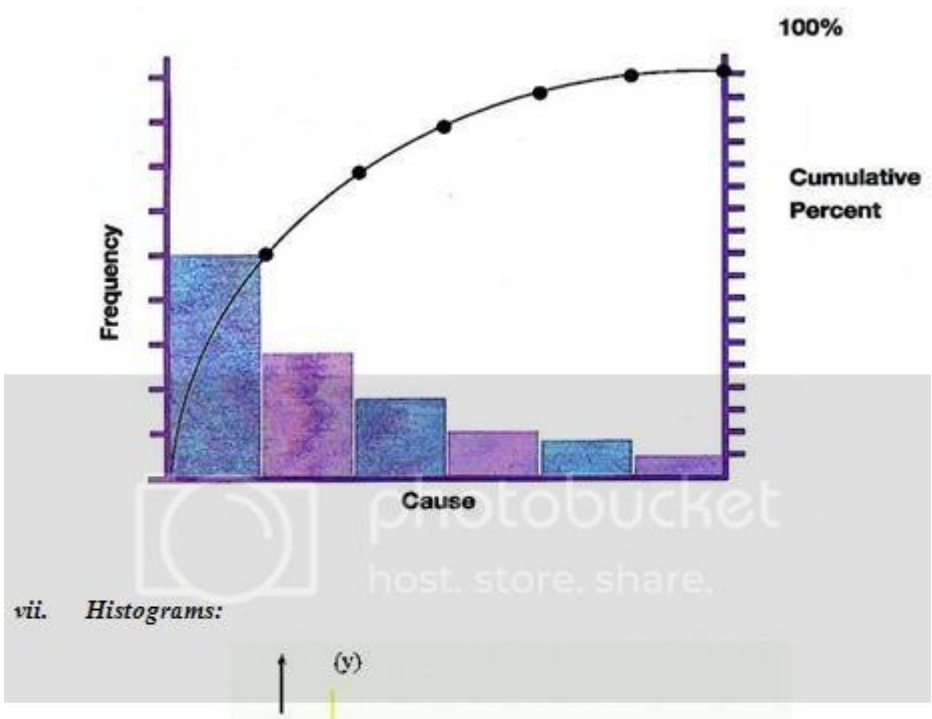
vi. Pareto Analysis

Pareto analysis is a technique used to identify quality problems based on their degree of importance. The logic behind Pareto analysis is that only a few quality problems are important, whereas many others are not critical.

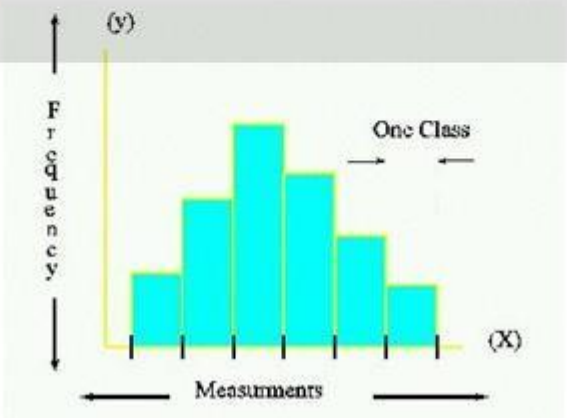
One way to use Pareto analysis is to develop a chart that ranks the causes of poor quality in decreasing order based on the percentage of defects each has caused. For example, a tally can be made of the number of defects that result from different causes, such as operator error, defective parts, or inaccurate machine calibrations,[1]



vii. Histograms:



vii. Histograms:



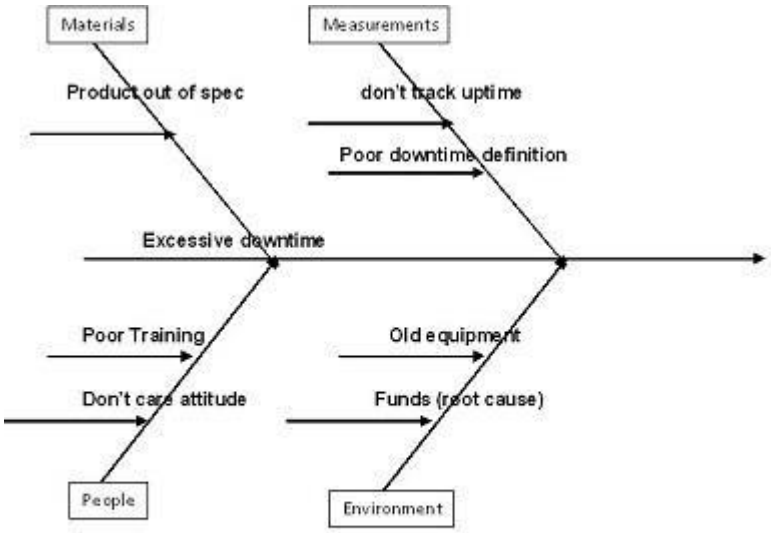
A histogram is a chart that shows the frequency distribution of observed values of a variable.We can see from the plot what type of distribution a particular variable displays. such as whether it has a normal distribution and whether the distribution is symmetrical.[1]

Quality Management Tools And Techniques

he tools and techniques most commonly used in Quality management and process improvement are:

- Cause and effect diagram
- Control Charts
- Histogram
- Pareto Charts
- Flow chart

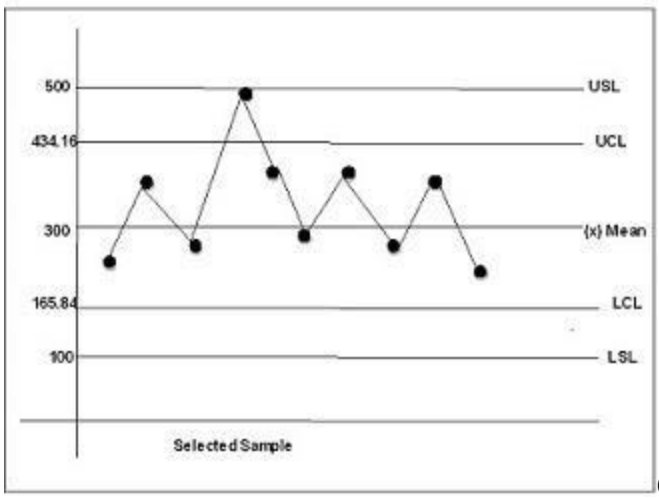
Cause and effect diagram



Cause and Effect Diagram

Cause and effect diagram is very helpful to find the root cause of the defect. Cause-and-effect diagrams show the relationship between the results of problems and the root cause of these problems. This diagram shows all the primary and secondary causes of a problem and the effect of all the proposed solutions. This Ishikawa diagram is also called fishbone diagram due to its fish-like shape. In the above diagram: poor training, old equipment, funds are the causes and “Excessive downtime” is the effect.

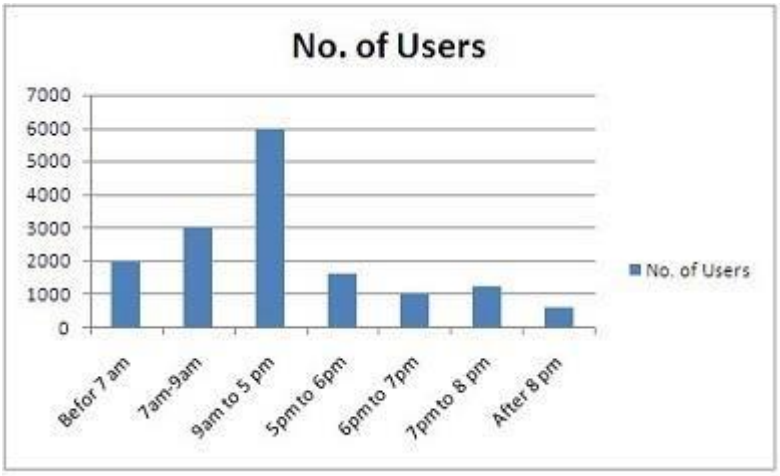
Control Charts



Control charts measure the results of processes over time and display the results in the form of a graph. By using control charts one can determine whether process variances are in control or out of control. A control chart is works on sample variance measurements, from the samples chosen and measured, the mean and standard deviation are determined.

Let's assume from a sample you have determined the measurement that mean is 300 and the standard deviation equals 44.72. Three standard deviations on either side of the mean become your upper and lower control points on this chart. In this case 3 standard deviations is equal to 300 +- (134.16). Therefore, if all control points fall within plus or minus three standard deviations on either side of the mean, the process is in control. If points fall outside the acceptable limits, the process is not in control and corrective action is needed. UCL and LCL are Upper control limit and lower control limit respectively. USL and LSL are upper specification limit and lower specification limit.

Histogram

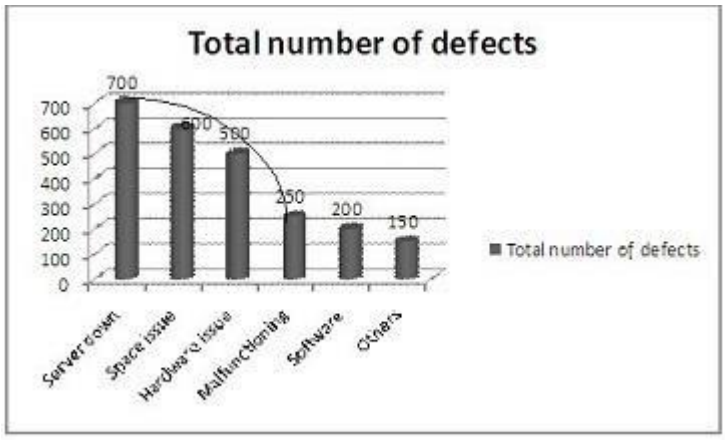


Histograms are a type of bar charts that depict the distribution of variables over time. This represents the distribution by mean. This graph may take different shapes based on the condition of the distribution. Histogram can be

used to measure something against time i.e. the graph is plotted with a variable on x-axis and time on the y-axis.

Consider the following example: The following histogram shows number of hits on the company's website in different time of the day. The x-axis shows the number of users or customers active on the website and the y-axis shows the time of the day.

Pareto chart



Pareto observed that 80 percent of issues occur due to 20% reasons. Over the years, others have shown that the 80/20 rule applies across many disciplines and areas. So it was a good idea to identify and focus on that category of defects which covers the maximum portion. It is a special form of vertical bar chart and used to identify the first few major sources responsible for the problem. In the figure below the total no. of defects are plotted against the reasons for those defects. The problems are rank-ordered according to their frequency and percentage of defects. By doing this ordering it is easier for you to identify the primary areas for corrective action.

Flowchart

Flowcharts are logical steps in a logical order so as to accomplish an objective. Flow charts are drawn with the use of geometrical objects like rectangular, rhombus, parallelogram, activities, decision points to in a process. Flowcharting can help identify where quality problems might occur on the project and how problems happen. There are different software tools in the market today for drawing flow charts, such as MS Visio.

The quality policy is a guideline created by the top management that describes what quality policies should be adopted by the project team, in line with other companies. These tools and techniques are very helpful for a project manager to understand it and incorporate it and deliver a quality product.

Cost of Quality (CoQ)

According to CIMA Official Terminology, CoQ is the difference between the actual cost of producing, selling and supporting products or services and the equivalent costs if there were no failures during production or usage. The cost of quality can be analysed into:

- **cost of conformance** – cost of achieving specified quality standards
- **cost of prevention** – costs incurred prior to or during production in order to prevent substandard or defective products or services from being produced
- **cost of appraisal** – costs incurred in order to ensure that outputs produced meet required quality standards
- **cost of non-conformance** - cost of failure to deliver the required standard of quality
- **cost of internal failure** – costs arising from inadequate quality which are identified before the transfer of ownership from supplier to purchaser
- **cost of external failure** – costs arising from inadequate quality discovered after the transfer of ownership from supplier to purchaser.

Total Quality Management (TQM)

CIMA Official Terminology describes TQM as the integrated and comprehensive system of planning and controlling all business functions so that products or services are produced which meet or exceed customer expectations. TQM is a philosophy of business behaviour, embracing principles such as employee involvement, continuous improvement at all levels and customer focus. It is also a collection of related techniques aimed at improving quality – such as full documentation of activities, clear goal-setting and performance measures from the customer perspective.

Originally developed in Japan in the 1950s, the aim of TQM is to get things 'right first time', an approach that increases prevention costs, such as system design, but helps to prevent internal and external failure costs. There is an emphasis on participation throughout the value chain, and a commitment to continuous improvement through constant reassessment of processes.

Kaizen

CIMA Official Terminology describes Kaizen as a Japanese term for continuous improvement in all aspects of an entity's performance, at every level.

The philosophy of Kaizen seeks to involve all levels of employees, encouraging suggestions for small incremental improvements across all areas of the business which over time have a major impact. In a manufacturing context, processes are standardised, assessed and then improved, with the ultimate result being decreased waste and increased productivity.

Six Sigma

CIMA Official Terminology describes Six Sigma as a methodology based on TQM to achieve very low defect rates. The 'sigma' refers to the Greek letter used to denote standard deviation, so

'six sigma' means that the error rate lies beyond six standard deviations from the mean. To achieve six sigma, an organisation must therefore produce not more than 3.4 defects per million products.
In practice, businesses use techniques such as statistical process control to monitor and chart processes, identifying exceptions to the upper and lower limits and aiming to reduce the number of faults.

EFQM Excellence Model

The EFQM model is a framework for management systems, developed by the European Foundation for Quality Management. It aims to assess performance; integrate and align existing tools, procedures and processes; introduce a way of thinking that encourages reflection and stimulates continuous improvement; and identify the key actions that are driving results.

A key feature of the model is a diagnostic framework that allows organisations to grade themselves against nine key criteria. These focus on the cause and effect relationship between how an organisation carries out its actions (enablers), and what these achieve (results).

Enablers	Results
Leadership Strategy People Partnerships and resources Processes, products and services	Customer results People results Society results Business results

What benefits do Quality Management Tools provide?

An effective quality management programme leads to higher quality processes and outputs. These in turn lead to greater customer satisfaction and improved profitability. Quality management encourages a culture of team working at all levels of the organisation, which in turn improves productivity. Human resources are recognised as a key organisational asset. Lower costs of failure, combined with shorter processing times, will result in cost savings.

Questions to consider when implementing Quality Management Tools

- How do we measure quality?
- Are senior management fully committed to the quality concept?
- Can we ensure buy-in across the organisation?
- What training will staff require?

Actions to take / Dos	Actions to Avoid / Don'ts
• Communicate the benefits of quality management across the organisation. Quality management techniques require buy-in and engagement at all levels in order to work effectively • Encourage a culture of teamwork, ensuring that managers work as part of their teams, rather than as overseers • Encourage a culture of ownership and responsibility among employees • Be aware that existing rewards may conflict with quality management by encouraging individualism over teamwork	• Don't be complacent – quality management is a long-term process seeking to make continual, small improvements over time • Avoid the use of too many quality measures – be selective and recognise that some may conflict with others

ean management is an approach to managing an organization that supports the concept of continuous improvement, a long-term approach to work that systematically seeks to achieve small, incremental changes in processes in order to improve efficiency and quality.

The primary purpose of lean management is to produce value for the customer through the optimization of resources and create a steady workflow based on real customer demands. It seeks to eliminate any waste of time, effort or money by identifying each step in a business process and then revising or cutting out steps that do not create value. The philosophy has its roots in manufacturing.

Lean management focuses on:

- Defining value from the standpoint of the end customer.
- Eliminating all waste in the business processes.
- Continuously improving all work processes, purposes and people.

Lean management facilitates shared leadership and responsibility; continuous improvement ensures that every employee contributes to the improvement process. The management method acts as a guide to building a successful and solid organization that is constantly progressing, identifying real problems and resolving them.

Lean management is based on the Toyota production system which was established in the late 1940s. Toyota put into practice the five principles of lean management with the goal being to decrease the amount of processes that were not producing value; this became known as the Toyota Way. By implementing the five principles, they found that significant improvements were made in efficiency, productivity, cost efficiency and cycle time.

5 PRINCIPLES OF LEAN MANAGEMENT

Lean management incorporates five guiding principles that are used by managers within an organization as the guidelines to the lean methodology. The five principles are:

1. Identify value
2. Value stream mapping
3. Create a continuous workflow
4. Establish a pull system
5. Facilitate continuous improvement

Identifying value, the first step in lean management, means finding the problem that the customer needs solved and making the product the solution. Specifically, the product must be the part of the solution that the customer will readily pay for. Any process or activity that does not add value -- meaning it does not add usefulness, importance or worth -- to the final product is considered waste and should be eliminated.

Value stream mapping refers to the process of mapping out the company's workflow, including all actions and people who contribute to the process of creating and delivering the end product to the consumer. Value stream mapping helps managers visualize which processes are led by what teams and identify the people responsible for measuring, evaluating and improving the process. This visualization helps managers determine which parts of the system do not bring value to the workflow.

Creating a continuous workflow means ensuring each team's workflow progresses smoothly and preventing any interruptions or bottlenecks that may occur with cross-functional teamwork. Kanban, a lean management technique that utilizes a visual cue to trigger action, is used to enable easy communication between teams so they can address what needs to be done and when it needs to be done by. Breaking the total work process into a collection of smaller parts and visualizing the workflow in this regard facilitates the feasible removal of process interruptions and roadblocks.

Developing a pull system ensures that the continuous workflow remains stable and guarantees that the teams deliver work assignments faster and with less effort. A pull system is a specific lean technique that decreases the waste of any production process. It ensure that new work is only started if there is a demand for it, thus providing the advantage of minimizing overhead and optimizing storage costs.

These four principles build the lean management system. However, the last principle -- continuous improvement -- is the most important step in the lean management method.

Facilitating continuous improvement refers to a variety of techniques that are used to identify what an organization has done, what it needs to do, any possible obstacles that may arise and how all members of the organization can make their work processes better. The lean management system is neither isolated nor unchanging and, therefore, issues may occur within

any of the other four steps. Ensuring all employees contribute to the continuous improvement of the workflow protects the organization whenever problems emerge.

Examples of lean management

The lean management principles can be used as a universal management tool to improve companies' overall performance.

Some examples of specific business and production processes that are based on the lean management concept include:

- Lean manufacturing
- Lean software development
- Lean six sigma
- Lean startup
- Value-based healthcare

Benefits of lean management

Lean management benefits organizations by focusing on improving all parts of the work process throughout every level of the company's hierarchy. Specifically, managers benefit from advantages such as:

- A more intelligent business process - The pull system ensures work is only carried out when there is an actual demand and need for it.
- Improved use of resources - The pull system also ensures the organization is only using resources when they are needed since it operates based on real customer demand.
- Improved focus - Lean management decreases the amount of wasteful activities, therefore allowing the workforce to increase their focus on tasks that produce value.
- Enhanced productivity and efficiency - Improved focus leads to a more productive and efficient workforce since attention is not given to unnecessary activities.

These major benefits work together to create a company that is more flexible and has the ability to address customer requirements in an improved and faster manner. Overall, the lean management system creates a solid production system that has a higher chance of improving a company's total performance.

LEAN MANUFACTURING METHODS AND TOOLS

There are many methods for improving the performance of organizations and a significant part of them are "Lean" ones, derived from the "Toyota Production System" or theorised in the books by J. Womack, T. Jones and D. Roos ("The machine that changed the world" and "Lean Thinking"). As is often the case, some methods have multiple origins, have been borrowed, adopted or modified over time and are therefore not all original "Lean" methods.

The important thing is not to know the exact origin of these techniques but to apply them well according to the context in order to reap the benefits.

The presentation below therefore presents the main "Lean" methods in a synthetic way without worrying about their true origin, even if it is often described.

5 whys

The Lean method of the "five whys" would have been designed by Sakichi Toyoda. It is one of the important methods used by Toyota to solve problems. The principle is not to stop at the first cause of a problem (the first why) but to analyze the problem until the root cause or causes are identified.

It is in fact more of a principle than a method of cause analysis because it is neither sufficiently structured nor'exact' (why 5 and not 4, 6? The root cause may very well be discovered in the 2nd).

What are the benefits?

It has the merit of simplicity to show that it is not necessary to stop at the obvious and make a rigorous analysis of a problem before being able to define solutions.

5S

The 5S is a cleaning and storage technique whose five letters mean:

- Seiri: **S**ort, separate the necessary from the unnecessary
- Seiton: **S**et in order
- Seiso: **S**hine, clean
- Seiketsu: Standardize
- Shitsuke: Sustain, self-discipline

These definitions are a representation of the meaning that these words convey in their use, and keeping the "S" as a mnemonic because their literal translation is slightly different.

What are the benefits?

The 5S Lean method is actually much more than a cleaning technique. When it is used according to its true intentions, the benefits are multiple:

- cost reduction by eliminating unnecessary tools or parts (Seiri) or standardizing them (Seiketsu)
- simplifying work and increasing productivity by reducing search times (Seiton)
- prevention of breakdowns by inspecting tools or machines during cleaning (Seiso) and detecting any anomalies
- reduction of the risk of accidents, for example by avoiding the cluttering of parts, or places made slippery by oil stains

5S PRACTICAL IMPLEMENTATION METHOD.

Andon

The word of Japanese origin is the combination of the two symbols 行 (go) and 灯 (light), which can be interpreted as "going where the light is".

In its professional application, the andon is a luminous display triggered when a problem is detected on a workstation in order to correct it as quickly as possible.

It can be triggered by an operator or automatically by the equipment where the problem occurs. Color codes can specify the type or level of urgency of the anomaly in order to conduct appropriate activities.

It was initially designed for large production workshops where visibility is very important. But it is applicable to other situations, such as call centres, and also in its computerised version where warning lights can be displayed on the PCs (or mobile) of the persons concerned.

What are the benefits?

It allows you to immediately and simply where a problem appears in order to correct it as quickly as possible. As it is visible, it can inform all concerned simultaneously so that everyone can intervene according to their responsibilities.

Autonomation or Jidoka

The Jidoka (自働化) is the automatic shutdown of a machine or equipment in case of defect detection. It is a word coined in 1896 by Sakichi Toyoda when he designed the first weaving machine that automatically stops when the yarn breaks; it means "automation with human touch" and has been translated into English by autonomation (contraction of automation and autonomous); it frees the human from the machine since it no longer needs constant monitoring if it stops itself.

It actually carries two important concepts in the original system of the Toyota Production System:

- the release of the human from the machine that allows an operator to operate several machines at once
- the "built-in Quality" by detecting quality problems as early as possible in order to solve them quickly; the complete concept even consists in identifying the root causes to correct them definitively.

What are the benefits?

Labour savings by allowing an operator to operate several machines at the same time. Savings in scrap or retouching, as well as an increase in induced productivity (first time right product) by correcting quality problems as soon as possible and preventing them from reoccurring.

Continuous flow

Continuous flow production consists of producing only one product at a time at each step of the process, unlike batch production, which consists of producing several products at a time. This seems at first glance less efficient than batch production because it does not allow to benefit from any possible scale effects of the latter.
However, it minimizes stock levels of work in progress and reduces production cycle time, as each product does not have to wait for others before moving on to the next production step. Moreover, unlike batch production, which can mask certain problems (thanks to intermediate waiting times), it requires the elimination of these problems (under penalty of stopping production instantly) and ultimately to make production more efficient.

What are the benefits?
Lower stock levels and shorter production cycle times.

Gemba

This is probably one of the most emblematic Lean method. Gemba, is a Japanese word (現場) that literally means "crime scene". Toyota, which initially used this term, has in fact replaced it with the term "Genchi genbutsu" which has a more positive connotation and means "going where the problem is encountered". The term most commonly used in the industry today is actually the "Gemba walk"...generally explained using the translation of the Genchi genbutsu.
Behind the differences in terms, there is a more important difference in philosophy. Whatever the term, it is the visit of a manager to the workplace. But Gemba, in its original version, emphasizes the inspection and verification of facts in order to make the right decisions. While the "Genchi genbutsu" version, which is closer to the American version of "management by wandering around", insists more on the informal side and listening of the employees who are visited.
Of course, a third approach can combine the first two.

What are the benefits?

A more detailed, accurate knowledge of working conditions and possible problems to be solved, and therefore better decisions.
Better mutual relations and understanding between managers and their teams.

Just-In-Time (JIT)

As its name suggests, the principle of Just-in-Time consists in each of the elements necessary for an operation on a product at a workstation arriving just at the moment when it is necessary for this operation with the right quantity. It is more a Lean principle than a Lean method because the activities and tools required (the method) to achieve Just-In-Time are quite complicated in practice; the method uses several techniques such as Kanban, Takt time or production smoothing (Heijunka) but may also require perfect coordination with external suppliers.

What are the benefits?

A reduction in the amount of products and parts outstanding.
In an induced way, the JIT contributes to the elimination of losses, the simplification and smoothing of production.

Heijunka (Level Scheduling)

Heijunka translation is levelling, which means smoothing the planning or workload in the industrial world. This method is fundamental to the success of "continuous flow" production in practice. It compensates for the fact that, in reality, orders rarely arrive at a regular rate. There are two types of levelling:

- volume levelling: as the orders are of different quantities each day, the smoothed production produces the average of the orders over a given period,
- levelling by product type: smoothing is a little more complicated, it is a question of combining each day the different products according to their production time to arrive at an identical (or almost identical) average time each day.

In practice, the two methods are combined. A visual means has been developed, the Heijunka box: it consists of boxes, each representing a type of product (in column) and a day of the week (in row), the number of sheets per box is the number of products of the type considered to be produced for that day; the production of the day is the sum of the products in the same column.

What are the benefits?
Allow continuous flow production when orders are not regular, i.e. in most cases.

Hoshin Kanri

The literal translation of Hoshin Kanri is "management of the direction". It is a method of deploying corporate policy or strategy, or in a broader sense of deploying major changes such as transformation programs. It is the opposite, or rather a complement to continuous improvement.

It is often considered a Lean method though its origins are a mixture of management by objectives (by P. Drucker), the teachings of W. Edwards Deming (notably known for the PDCA) and those of Joseph M. Juran in Japan where it was developed, notably by a subsidiary of Hewlett-Packard.

This method has three pillars:

- a cascaded deployment based on the definition of the vision: the management sets the main directions that are applied in the whole organisation ("top down" process)
- an iterative and participative process at each hierarchical level: allows good understanding, adaptation to reality and appropriation by the teams at each level; this process is often called "catchball" (from a child's game with ball exchange)
- Short and long PDCA cycles: allows to correct and improve the deployment over several time horizons.

The method consists of 7 steps:

1. Define the vision
2. Define strategic or transformational / breakthrough objectives
3. Define annual objectives: translate previous objectives, which are long-term objectives, into annual objectives
4. Deploy annual objectives: consists of applying the previous objectives (which are from the general management level) to the lower levels in a way that is adapted to the responsibilities and activities of these levels
5. Implement annual objectives: implementation really begins with a measurement of results against objectives
6. Monthly review: PDCA cycle to improve execution
7. Annual review: PDCA cycle to improve the whole, starting with the definition of the vision

One tool used is the Hoshin Kanri matrix or X matrix, which synthesises the relationship between the Breakthrough Objectives, annual objectives, breakthrough priorities and quantified concrete objectives.

What are the benefits?

The main benefit is the successful implementation of the vision in the organization. It implies a good alignment of the organization, a pragmatic approach adapted to the operational modes and a commitment of the staff to the vision and operational modes.

Kaizen

Kaizen is probably the most known Lean method. Kaizen (改善?) is the combination of kai and zen that means "change" and "good". This is simply what we have translated as "continuous improvement". It is therefore not a method but a principle or philosophy that is at the heart of Lean.

Kaizen (chantier) - Kaikaku

In the West, the word Kaizen is often used in the context of a "Kaizen event", or "Kaizen Blitz". It is actually a rather curious translation because it is the opposite of Kaizen (which implies progressive improvements) in making radical changes; the Japanese more precisely call it by another name, Kaikaku (改革) which means reform.

A Kaizen Blitz is generally a one- to five-day workshop (the entire week), focused on a specific area and theme, with the objective of making a significant change.

What are the benefits?

Achieve visible and faster results than with the more traditional continuous improvement.

Kanban

Kanban (看板) means "sign" or "card" in Japanese. This is the key method for implementing "pull" continuous flow production.

It is used to trigger the production of parts between workshops, starting from the lowest workstation and working up to the upstream workstations.

The principle is as follows:

- a card (Kanban) is attached to each part to be processed at the downstream workstation
- when the downstream station has completed its operations on the part, the card returns to the card table (Kanban board) of the upstream station
- for the upstream station, the card is a "production order" and it starts its operations when there is a card in its card box.
- there can be several cards in the Kanban board and the production of the upstream item starts when the number of cards exceeds a certain level; but this level must be minimal otherwise it increases the stock of work in progress.

To be implemented, it requires that the entire production perimeter concerned be organised in a continuous "pull" flow.

What are the benefits?

A visual method for planning an entire workshop without the need for expensive MRP software or planning staff.

It is simple to implement once the entire system is designed to operate as a pull flow.

Plan-Do-Check-Act (PDCA)

The PDCA originated from a seminar sponsored by the Japanese Union of Scientists and Engineers (JUSE), where W. Edwards Deming presented a modified Shewhart Cycle. It is a method of designing and manufacturing a product in accordance with specifications; JUSE, and in particular Kaoru Ishikawa, has transposed it to be used as a more general method called PDCA. It has become a fundamental element of Lean continuous improvement principle. It is also called the Deming Wheel. Its four steps are:

- Plan: plan the actions, after defining what you want to implement and the objectives
- Do: carry out the actions
- Check: monitor the achievement of actions and objectives, understand the results
- Act: Act, implement corrective or improvement actions

What are the benefits?

The benefits depend on the context and objectives of the use of the PDCA. In an efficiency context, it makes it possible to implement actions in order to obtain the expected results; in a more experimental context, it makes it possible to test an idea or concept and modify them after a learning phase. More generally, it allows for continuous improvement.

Poka-Yoke (mistake-proofing)

The Poka-Yoke (アンチエラー) is a mistake-proofing system; it prevents assembly, assembly, connection or even procedural errors. Three types of system can be distinguished:

- mechanical: two parts, due to their mechanical design, can only be assembled or connected in one direction.
- warning: an audible or visual signal is triggered if an operation is not performed
- procedural: a system blocks the continuation of operations if an operation is not performed or not performed in the right order

Single Minute Exchange of Die (SMED)

It is a Lean method developed by Shigeo Shingo at Toyota. Its objective is to reduce tool changeover times in production as much as possible.

The method consists of five steps

1. Identify the operations performed: all operations performed must be identified and measured, including waiting times
2. Determine internal and external operations
    - internal operations are those specific to the change operation that require production to be stopped

    - external operations are those that can take place before or during production: preparation of parts or tools, presettings...
3. Group external operations together: this grouping already reduces production downtime by eliminating the times of these operations from downtime
4. Reduce the time of internal operations: review in detail each of these operations and determine if they can be deleted, modified, accelerated...
5. Reduce the time of external operations: has no direct impact but can nevertheless improve efficiency or reduce costs

It will of course be possible to complete this method with standardisation or continuous improvement steps.

Standardised Work

Although it is a fundamental pillar of the Toyota Production System and Lean, it must be recognised that the father of standardization is Henry Ford. It consists in standardising processes, operating procedures, tools and also by extending parts and components.

What are the benefits?

They are to improve the reproducibility and stability of production, to facilitate the learning or sharing of methods between teams as well as the interchangeability of people between teams, and finally to reduce the cost of manufacturing standardised tools or parts.

Takt time

Takt comes from German and means cadence.

Takt time is not strictly speaking a method; it is the essential measuring element of the continuous flow production method. This is the production rate of each product, which must be identical in theory to the sales rate. Ideally, if all production steps are well balanced (according to the Heijunka method), each at a duration equal to Takt time.

Total Productive Maintenance (TPM)

Total Productive Maintenance was developed in the late 1960s at a Toyota parts supplier, Nippondenso, and formalized by Seiichi Nakajima, Director of the Japan Institute of Plant Management (JIPM).

This method is based on two key principles, included in its name:

- Productive: to carry out as much as possible the maintenance without stopping production
- Total: include all factors influencing the proper functioning of the machines and involve everyone

The JIPM has defined eight pillars of TPM:

1. Autonomous maintenance: simple operations (cleaning, lubrication, inspection, etc.) carried out by production operators and preventing breakdowns or identifying anomalies as soon as possible
2. Case by case improvement (Kobetsu-Kaizen): it is the equivalent of Kaizen in the TPS method
3. Scheduled maintenance: it prevents breakdowns through preventive work
4. Training and knowledge management: training of maintenance technicians and operators allows for better maintenance
5. Maintenance from the design stage: maintenance is taken into account in the design of machines or products to facilitate maintenance operations
6. Quality Maintenance: maintenance contributes to quality by avoiding or limiting defects due to machine malfunction.
7. Health, Safety and Environment: this pillar ensures a good environment for employees and helps to develop a culture that encourages attention to equipment.
8. Office maintenance: ensure that the support functions understand the challenges of maintenance and can provide support in addition to developing their sense of improvement on their own processes.

What are the benefits?
TPM has three main benefits:

- the involvement of all in maintenance and therefore better prevention combined with control of maintenance costs
- reduce machine downtime, in particular through maintenance without stopping production
- a holistic approach with consideration of all factors

VALUE STREAM MAPPING (VSM)

The value stream mapping is an analysis tool that makes it possible to identify and visualize in a synthetic way all the physical and information flows of a process.

The synthetic and visual aspect is possible thanks to the use of standardized symbols and a description that must remain at a macroscopic level without being exhaustive.

Several pieces of information are characteristic of flow mapping:

- the joint representation of physical and information flows (in particular production orders or orders)
- the representation of the travels and stock stages in addition to the other pure production stages
- the identification of key volume and duration figures for each step
- the cumulative time line by identifying the processing times (including inspection times, even if they are not value-added times) and the times between operations (movements, waiting, stocks)
- identification of problems

A Value Stream Mapping can be performed for production processes as well as for service processes, product design, software development or others.

What are the benefits?

The simple visualisation allows an easy exchange between the people concerned to have a common vision of the reality of the process.

In particular, it makes it possible to visualize the total cycle time and to understand that it is the share of production time in relation to inter-operation time.
It is an ideal basis for identifying areas to be investigated in more detail to understand malfunctions, reduce non-value-added activities and reduce stocks of work in progress.

Waste reduction
One of the fundamental principles of Lean is the reduction of waste, which is also more of a Lean principle than a Lean method. According to Taichi Ohno there are three types of waste:

- Muda: activities without added value for the final product; some of its activities are nevertheless necessary, such as quality controls or adjustments
- Muri: excessive or too difficult activities
- Mura: variability undergone

The reduction of waste primarily concerns unnecessary Muda. There are 8 types of Muda to reduce:

1. Overproduction
2. Inventory
3. Unnecessary transport or travel (materials, parts, products, documents)
4. Over processing
4. Unnecessary motion
5. Defects and rejects
6. Waiting time
7. Underutilization of skills; this waste was added after the first seven initially defined by Taichi Ohno

What are the benefits?

The identification and systematic reduction of waste is a major lever for simplifying processes and reducing their variability.

JIT

Just-in-time, or JIT, is a method of inventory management in which only as many goods are received from suppliers as they are needed. The main objective of this method is to reduce inventory holding costs and increase total revenue.

Just-in-time (JIT) inventory management, also know as lean manufacturing and sometimes as the Toyota production system (TPS), is an inventory strategy that manufacturers use to increase efficiency. This process involves ordering and receiving inventory for production and customer sales only when it is needed to produce those items, and not before.

This type of **inventory management** gives the firm many benefits, but is not without its downsides, and relies very much on factors such as a strong, fast, and efficient network of suppliers.

The Purpose of JIT

Ordering inventory on an as-needed basis means that the company does not hold any safety stock, and works with continuously low inventory levels. This strategy helps companies lower their inventory carrying costs, increase efficiency, and reduce waste. JIT requires manufacturers to be very precise in forecasting the demand for their products.

Just-in-time inventory management is a positive cost-cutting inventory management strategy, although it can also lead to the item(s) being out of stock. The goal of JIT is to increase a company's return on investment by decreasing unnecessary costs.

Some alternate inventory management systems exist, in which short-cycle manufacturing (SCM), continuous-flow manufacturing (CFM), and demand-flow manufacturing (DFM) are included.

The JIT inventory system is a step away from the old "simple-case" policy, where factories held much greater inventories of inventory and raw materials if they wanted to produce more units due to higher demands.

History of the JIT Inventory

The management technique was found in Japan and is often attributed to Toyota. However, many believe that Japan's shipyards were the first to create and successfully execute this strategy. Its origins are seen as three-fold: Japan's post-war lack of cash, lack of space for big factories and inventory, and Japan's lack of natural resources. Thus the Japanese "leaned out" their processes, and JIT was born.

News about the process and success of JIT/TPS reached Western shores in 1977 with executions in the U.S. and other developed countries beginning in 1980.

Benefits Of Just-In-Time Inventory

Just in time needs careful planning of the entire supply chain and usage of the best software to carry out the entire process till delivery, which increases efficiency and eliminates the possibility of error as each process is observed. **Here are some of the important benefits of a just-in-time inventory management system:**

Reduces inventory waste

A just-in-time strategy eradicates overproduction, which happens when the supply of an item in the market is more than the demand and leads to the acquisition of waste inventories. These unsalable products turn into inventory dead stock, which leads to the increment of waste and consumes inventory space. In a just-in-time system, you order only what you need, so there's no risk of the acquisition of waste inventory.

Decreases the cost of warehousing

Warehousing is very costly, and more inventory than you need can double your holding costs. In a just-in-time system, the warehouse holding costs are kept to a minimum. Because you order only when your customer orders something, your item has already been sold before it reached you, so there is no need to store your items for long. Companies that follow the just-in-time inventory model will be able to minimize the number of items in their warehouses or eradicate the need for warehousing.

Gives the manufacturer more control

In a JIT model, the manufacturer has full control over the manufacturing process, which works on a demand-pull basis. They can answer their customers' needs by quickly increasing the manufacturing of an in-demand product and reducing the manufacturing of slow-moving items. This makes the JIT model flexible and able to serve ever-changing market needs. For instance, once an order has been issued, Toyota will not buy raw materials. This has allowed the company to keep minimal inventory, thereby lowering its costs and allowing it to quickly adapt to changes in demand without having to worry about existing inventory.

Local Sourcing

Since just-in-time needs you to start manufacturing only when something is ordered, you need to source your raw materials locally as they will be delivered to your unit much earlier. Other than that, local sourcing lowers the transportation time and cost which is involved. This in turn provides the need for many complementary businesses to run in parallel thereby improving the employment rates in that certain demographic.

Smaller investments

In a JIT model, only necessary stocks are acquired and therefore less working capital is needed for finance procurement. So, because of the less amount of stock held in the inventory, the organization's return on investment would be high. The Just-in-time model uses the "right first time" concept whose meaning is to do the things right the first time when it's done, thereby lowering inspection and rework costs. This needs less amount of investment for the company, less money reinvested for correcting errors, and more profit generated out of selling an item.

Easily Identifiable

With so little inventory with the company, defective inventory articles are easier to identify and correct, resulting in lower scrap costs.

Lower Processing Time

An efficiently executed JIT system should reduce the amount of time required to produce products, which may reduce the quoted lead times given to customers placing orders.

Easier Engineering Change Orders

It is much easier to execute engineering change orders to existing products because there are few stocks of raw materials stored by the company to draw down before you can make changes to a product.

Good Quality

Supplier quality is certified in advance, so their deliveries can be sent straight to the manufacturing area, instead of piling up in the receiving area to await inspection.

Production Cells

Employees walk individual parts through the procedures in a work cell, as a result, lowering scrap levels. Doing so also eradicates the work-in-process queues that typically build up in front of a more specialized work station.

Reduced Production Runs

Fast equipment setup times make it cost-efficient to create very short production runs, which lowers the investment in finished goods inventory.

Advantages and Disadvantages of Just-In-Time Systems

Advantages of Adopting Just-In-Time include:

- Just-in-time approach keeps stock holding costs to a minimum level. The released capacity results in better utilization of space and bears a favourable impact on the insurance premiums and rent that would otherwise be needed to be made.
- The just-in-time approach helps to eliminate waste. Chances of expired or out of date products; do not arise at all.
- As under this management method, only essential stocks which are required for to manufacturing are obtained, thus less working capital is required.
- Under this approach, a minimum re-ordering level is set, and only when that level is reached, order for fresh stocks are made and thus this becomes a boon to inventory management too.
- Due to the abovementioned low level of stocks held, the ROI (Return On Investment) of the organizations be high in general.

- As this approach works on a demand-pull basis, all goods produced would be sold, and thus it includes changes in demand with unanticipated ease. This makes JIT appealing today, where the market demand is fickle and somewhat volatile.
- JIT emphasizes the 'right-first-time' concept, so that rework costs and the cost of inspection is minimized.
- By following JIT greater efficiency and High-quality products can be derived.
- Better relationships are fostered along the production chain under a JIT system.
- Higher customer satisfaction due to continuous communication with the customer.
- Just In Time adoption result in the elimination of overproduction.

Disadvantages of Adopting JIT Systems

- JIT approach states ZERO tolerance for mistakes, making re-work difficult in practice, as inventory is kept to a minimum level.
- A successful application of JIT requires a high reliance on suppliers, whose performance is outside the purview of the manufacturer.
- Due to no buffers in JIT, production line idling and downtime can occur which would have an unfavourable effect on the production process and also on the finances.
- Chances are quite high of not meeting an unexpected increase in orders as there will be no excess inventory of finished goods.
- Transaction costs would be comparatively high depending upon the frequency of transactions.
- JIT may have certain negative effects on the environment due to the frequent deliveries as the same would result in higher use and cost of transportation, which in turn would consume more fossil fuels.

JIT ELEMENTS

The detailed description of the JIT elements after reviewed from the literature is:
Buffer stock removal Buffer stock removal is a JIT technique to reduce non-value added activities. A buffer stock approach is an attempt of storage to stabilise prices in the market. Buffer stock has strong relationship with batch size and JIT purchase, and weak relationship with process and product standardisation. Inventory covers up a lot of wasteful practices. Better maintained Machines, improved quality practices and delivery times, streamlined machine setup procedures and efficient labour and equipment utilisation permits the organisation to operate with less inventory and cost, and faster response times in meeting customer needs. Buffer stock is more of production/purchase problem. Since maintenance is a process in nature with standardisation approach, thus buffer stock removal is least
Significant to JIT maintenance.
Continuous improvement
Continuous improvement (kaizen) means change for better. The word also refers to continuous. It is widely researched in production systems. There exist no processes that are perfect, thus a need for continuous improvement is always there. Companies that have applied this philosophy have gained great economic benefits. Maintenance is an activity to change for better and it requires continuous improvement. A maintenance plan should include strategies for continuous improvement, since plan is totally perfect; it can be improved. Thus, kaizen needs to be considered as a JIT element for maintenance.

Effective communication
Effective communication in JIT aims in time and material waste reduction. And maintenance is an activity for which time is more valuable. The maintenance time need to be minimised. Thus, for effective utilisation of maintenance time effectivecommunication has a pilot role. Effective communication between different departments (especially purchase and inventory) and among the maintenance personals is always beneficial for the growth of the organisation. It is necessary to understand what actually one wants to express, thus effective communication is necessary activity of maintenance.
The communication medium and language has a great impact on maintenance activity.

Employee empowerment
Employee empowerment and involvement is a necessary activity. Successful implementation of JIT in an organisation largely depends of front-line employees. Their role is to collaboratively work with higher and lower levels of hierarchy. Their role is to work for improvement of work processes, understand quality measures, solve problems,
generate broader view of the production process, ensure inter-connectivity of workers and decide basic maintenance practices, to understand the condition of machines and equipment's and bility to meet quality and production requirements. Thus, employee empowerment and involvement is a key element of maintenance practice, and needs to be considered as JIT element for aintenance.

error prevention: – error prevention (poke-yoke) is a tool for inadvertent error prevention and to prevent errors originating in the mistake to reduce quality control (QC). Application of poke yoke in maintenance will reduce breakdown and improve the availability of machines as it aims to eliminate possibility of the error occurrence. Frequent and reliable delivery is desirable from any manufacturing unit. The reliability of the delivery depend the availability of the machines and equipment's. The availability in turn is maintained by reduced uncertainty. Thus, Maintenance is at third level of importance for frequent and reliable delivery. Kanban is the scheduling system for JIT and lean manufacturing. It is also an inventory control tool for supply chain. Kanban is an information system. One could also consider that kanban is a very efficient tool to ensure proper delivery of information in the production line and, thus, avoid mistakes. It is an effective tool to support manufacturing. Thus, the scheduling tool is of less importance to maintenance.

Long-term QC
Long-term QC commitment is not an overnight achievement. It is the result of close agreement of JIT principles with hard work over many quality plans. It can happen when the system has least uncertainty. It requires each worker to control the quality of the processes carried out. Both JIT and quality are philosophies applied to production systems, and philosophies are not implemented within a short time since they must be integrated into the lifestyle of workers. A long-term quality plan helps to generate strategies to eliminate waste in the production system, which would increase fluidity of materials.

Multi-functional worker
Multi-functional worker refers to the capability of the workers to perform various activities. In case of unavailability of any worker, other could perform the required task. The work remains

unaffected. It was considered to be the most important JIT element by Martínez-Jurado et al. (2014) for the success of JIT philosophy, hence considered as JIT element in maintenance. Total preventive maintenance – this technique of maintenance is helpful to improve the quality, flexibility and cost by increasing precise time bound enhancement action plans. It is considered essential to obtain proper performance and efficiency indicators in companies. The action plan is carried out prior to the breakdown occurs and thus the JIT element is required for JIT element in maintenance.

QC authority to worker

This element of JIT provides authority to the workers to take corrective action to improve the quality of the product. Since the activities during the production process add value to a product to obtain the desired characteristics, quality needs to be analysed during the production process. If mistakes occur during any stage of the production; the product gets affected and requires additional activities to get it corrected. The element needs to be considered for maintenance to ensure proper and in-time maintenance.

Education and training

Education and training to workers ensures must be closely linked because the product quality depends not only on machinery and equipment, but also on the education and training of managers who develop plans and workers who execute these plans, OOI (2014). There exists a strong bond between motivation and the educational levels of operators. Set up time reduction is required to increase the production rate and maximise the profits. The programs to reduce setup times for machines and equipment are based both on the analysis of unnecessary movements by operators and machines and the design of these machines. It is important to highlight that in order to meet short preparation times highly trained and skilled working personals are required

Standardisation

It is one of the essential elements required for successful implementation of JIT. By applying the concept of standardisation, easy availability and inter-changeability of tools and parts is ensured, making the processes simple. Statistical process control plays a key role in the success of the JIT program. It controls the process through performance indices and is equally important in all phases and departments of a company or industry. Statistical QC – the system generated statistics are the real performance indicators of the company status. Statistical QC is a snapshot of health of companies. Appropriate QC plans and programs with their application by statistical QC are essential for JIT implementation. Thus, the element needs to be considered for maintenance.

Total QC

Quality is a major element to reduce uncertainty and non-value-added activity in an organisation. JIT concept for quality is ‘do it right the first time’. It eliminates time and materials waste. Maintenance is a time dependent activity, thus the QC element is strongly recommended JIT manufacturing element to be considered as JIT maintenance element. Total QC as a JIT element for maintenance includes selecting right person for right maintenance activity, education and training of maintenance personals, equipping the maintenance team with special and updated tools and techniques, giving valuable consideration to the feedback of maintenance personals, encourage computer assisted maintenance management system, need to work for error prevention instead of error detection

Quality certification of supplier helps in supplies selection for future use. Regular quality auditing helps to improve quality and list out the strengths and weaknesses in the system. Short lead time is the outcome by application of JIT. Small lot size reduces complexity. A standard container helps in easy counting, assembly processes and inventory handling. Layout improvement involves futuristic plans. Vendor rating identifies best vendors and starts a competition among vendors to supply quality items and service. Scheduling flexibility/under capacity scheduling reduces complexity and ensures on time delivery

Zero defect targets improve quality. 100% quality inspection ensures no rejection and no customer complaints. Waste elimination is the key feature and element of JIT in all business functions. Uninterrupted work flow increases the availability of the machines and the system. Top management commitment works like a soul in the human resources. Inventory management is again the primary element of JIT. MRP is an intelligent approach for resources management. Automation improves quality, reduces rejections and increases productivity. Process simplification is required for easy working. Process flexibility ensures on time delivery and shorter make span. JIT purchasing reduces inventory. Leveling of production improves processes functions and workforces. Pull system reduces inventory. Strong buyer-supplier relationship develops confidence in entrepreneur for higher investment for the project. Team work improves the processes in all respects. Low cost is the desire of everyone connected to the product. From the above listed JIT elements, the following elements are selected as JIT elements for application in maintenance. Based on the described in depth theoretical analysis of the reviewed literature and brain storming with maintenance managers of JIT elements implemented industries thefollowing 18 JIT elements are selected from 38 JIT elements to analyse implementation of JIT in maintenance sector of Indian context.

WHAT IS SIX SIGMA?

Six Sigma is a quality management methodology used to help businesses improve current processes, products or services by discovering and eliminating defects. The goal is to streamline quality control in manufacturing or business processes so there is little to no variance throughout.

Six Sigma was trademarked by Motorola in 1993, but it references the Greek letter sigma, which is a statistical symbol that represents a standard deviation. Motorola used the term because a Six Sigma process is expected to be defect-free 99.99966 percent of the time — allowing for 3.4 defective features for every million opportunities. Motorola initially set this goal for its own manufacturing operations, but it quickly became a buzzword and widely adopted standard.

Six Sigma is specifically designed to help large organizations with quality management. In 1998, Jack Welch, CEO of GE, helped thrust Six Sigma into the limelight by donating upwards of $1 million as a thank you to the company, recognizing how Six Sigma positively impacted GE’s operations and promoting the process for large organizations. After that, Fortune 500 companies followed suit and Six Sigma has been popular with large organizations ever since.

SIX SIGMA PRINCIPLES

The goal in any Six Sigma project is to identify and eliminate any defects that are causing variations in quality by defining a sequence of steps around a certain target. The most common examples you'll find use the targets "smaller is better, larger is better or nominal is best."

- **Smaller is Better** creates an "upper specification limit," such as having a target of zero for defects or rejected parts.
- **Larger is Better** involves a "lower specification limit," such as test scores — where the target is 100 percent.
- **Nominal is Best** looks at the middle ground — a customer service rep needs to spend enough time on the phone to troubleshoot a problem, but not so long that they lose productivity.

The process aims to bring data and statistics into the mesh to help objectively identify errors and defects that will impact quality. It's designed to fit a variety of business goals, allowing organizations to define objectives around specific industry needs.

SIX SIGMA METHODOLOGIES

In practice, Six Sigma follows one of two sub-methodologies: DMAIC and DMADV:

SIX SIGMA DMAIC

The Six Sigma DMAIC project methodology includes five phases, each represented as a letter in the DMAIC acronym. These include:

- **Define** the problem, the customer, the project requirements and the ultimate goals and expectations of the customer.
- **Measure** performance of the current process by establishing a data collection plan to determine defects and gather metrics.
- **Analyze** the process to establish root cause of variations and defects to identify issues with the current strategy that stand in the way of the end goal.
- **Improve** the process by eliminating the root causes of defects through innovative solutions.
- **Control** the new process to avoid falling into old habits and to ensure it stays on track.

Six Sigma DMADV

The Six Sigma DMADV, also known as the Design For Six Sigma (DFSS), includes five stages:

- **Define** realistic goals that suit the customer's requirements or the business strategy.
- **Measure** and identify the customer's critical to quality (CTQ) requirements and translate them into clear project goals.
- **Analyze** multiple options and alternatives for the customer along with the estimated total life cycle of the project.
- **Design** the process at a high level before moving onto a more detailed version that will become the prototype to identify errors and make modifications.

- **Verify** that the final iteration of the product or process is approved by all customers and clients — whether internal or external.

DMAIC vs. DMADV

The DMAIC and DMADV methodologies seem similar, but they have different use cases. The DMAIC methodology is designed for existing process or products that aren't meeting customers' needs or performing to standards. When a business needs to develop a product or process that doesn't already exist or when a product has been optimized but still falls short, that's when you want to use DMADV.

Determining a Six Sigma project

To find projects in your organization that would benefit from Six Sigma they need to fit some criteria:

- Each project needs to have a clear process of inputs and outputs.
- Don't go into the project with a pre-determined solution — that means you already know the fix.
- Focus on reducing "operation variation" to make it easier for untrained operators.
- Project needs to be approached with knowledge of variations in process inputs and how to control and eliminate defects.

iSixSigma offers the example of a "slow cycle time at Station 30" due to defective parts coming from "Station 20." A "non-Six Sigma solution" would attempt to rebalance the assembly line, while re-doing the work, keeping cycle time low and not spending on labor. A Six Sigma solution would be to "investigate and control key inputs that contribute" to defective parts coming from Station 20 to keep it from happening again in the future. In this case, the Six Sigma focus looks at proactively eliminating the defect, while a non-Six Sigma approach simply reacts to the problem without identifying the cause.

For a closer look at where to apply Six Sigma, see "How to find the perfect project for Six Sigma success."

Six Sigma implementation roles

A key concept in Six Sigma is the idea of establishing clear leadership roles and a hierarchy for quality management. The key roles for Six Sigma implementation include:

- **Executive leadership:** This includes the CEO and other executive management who are charged with developing the vision for Six Sigma implementation. Leaders should also be responsible for encouraging new ideas and supplying the resources to act on innovation.
- **Champions:** Typically found in upper management, Champions are the people responsible for acting on executive leadership's vision and acting as mentors to black belts.

- **Master Black Belts:** These workers spend all their time on Six Sigma methodology, either by guiding Black or Green Belts or helping Champions. They're picked out by Champions and are tasked with ensuring consistency in the Six Sigma strategy.
- **Black Belts:** Working below Master Black Belts, Black Belts are responsible for executing on the Six Sigma strategy and typically act as leaders for specific tasks.
- **Green Belts:** Guided by Black Belts, Green Belts are new to the Six Sigma methodology and start learning it while maintaining their other job responsibilities.

You may find other belts — like white, yellow and orange. These are adopted by organizations to represent employees with some Six Sigma training, but aren't involved in the overall project.

Six sigma certification and training

Certification and training are offered directly by businesses, with GE and Motorola paving the way by being the first to develop Six Sigma certification programs to verify proficiency in the Six Sigma methodology. After that, large companies and universities followed suit, offering their own version of a Six Sigma certification program.

However, there isn't much oversight to what qualifies as Six Sigma certification and the criteria for Green Belt and Black Belt certification can vary. Certification programs are offered through businesses, universities, professional associations and for-profit training organizations. Some notable organizations include:

- American Society for Quality
- Dartmouth College
- Boston University
- GE
- Accenture
- IASSC
- Cornell University
- Motorola Solutions
- Purdue University

Some organizations offer Six Sigma accreditation — the IASSC offers Lean Six Sigma credentialing and accredited training providers. The Council for Six Sigma Certification also offers a list of accredited Six Sigma providers. Ultimately, when choosing a Six Sigma certification or training program, it's important to do your research to ensure the organization, university or third-party vendor offers the right training for your needs and has the right qualifications.

For more IT management certifications, see "10 IT management certifications for IT leaders."

SIX SIGMA CRITICISMS

Six Sigma is popular with large organizations, but it's not as realistic for businesses with less than 500 employees. While certain aspects of the methodology can certainly apply to small

businesses, it's not as relevant. There are also cautions around a growing industry catering to Six Sigma certifications and training. You want to do your research to ensure any third party offering Six Sigma services are highly qualified to do so.

Other cautions point to Six Sigma's focus on improving what already exists, while much of the business world is pivoting to innovating around new technology. So, while it might help uphold legacy systems and current products, it doesn't leave much room for disrupting an industry or developing fresh products and services. Although, iSixSigma counters this claim, pointing out that it can help bring efficiency to process, reducing waste and cost, which allows businesses to find the funds for innovation.

SIX SIGMA AND QUALITY MANAGEMENT

Six Sigma is a business management strategy which aims at improving the quality of processes by minimizing and eventually removing the errors and variations. The concept of Six Sigma was introduced by Motorola in 1986, but was popularized by Jack Welch who incorporated the strategy in his business processes at General Electric. The concept of Six Sigma came into existence when one of Motorola's senior executives complained of Motorola's bad quality. Bill Smith eventually formulated the methodology in 1986.

Quality plays an important role in the success and failure of an organization. Neglecting an important aspect like quality, will not let you survive in the long run. **Six Sigma ensures superior quality of products by removing the defects in the processes and systems**. Six sigma is a process which helps in improving the overall processes and systems by identifying and eventually removing the hurdles which might stop the organization to reach the levels of perfection. According to sigma, any sort of challenge which comes across in an organization's processes is considered to be a defect and needs to be eliminated.

Organizations practicing Six Sigma create special levels for employees within the organization. Such levels are called as: "Green belts", "Black belts" and so on. Individuals certified with any of these belts are often experts in six sigma process. **According to Six Sigma any process which does not lead to customer satisfaction is referred to as a defect and has to be eliminated from the system to ensure superior quality of products and services**. Every organization strives hard to maintain excellent quality of its brand and the process of six sigma ensures the same by removing various defects and errors which come in the way of customer satisfaction.

The process of Six Sigma originated in manufacturing processes but now it finds its use in other businesses as well. Proper budgets and resources need to be allocated for the implementation of Six Sigma in organizations.

Following are the two Six Sigma methods:

- DMAIC
- DMADV

DMAIC focuses on improving existing business practices. DMADV, on the other hand focuses on creating new strategies and policies.

DMAIC has Five Phases

D - Define the Problem. In the first phase, various problems which need to be addressed to are clearly defined. Feedbacks are taken from customers as to what they feel about a particular product or service. Feedbacks are carefully monitored to understand problem areas and their root causes.

M - Measure and find out the key points of the current process. Once the problem is identified, employees collect relevant data which would give an insight into current processes.

A - Analyze the data. The information collected in the second stage is thoroughly verified. The root cause of the defects are carefully studied and investigated as to find out how they are affecting the entire process.

I - Improve the current processes based on the research and analysis done in the previous stage. Efforts are made to create new projects which would ensure superior quality.

C - Control the processes so that they do not lead to defects.

DMADV Method

D - Design strategies and processes which ensure hundred percent customer satisfaction.

M - Measure and identify parameters that are important for quality.

A - Analyze and develop high level alternatives to ensure superior quality.

D - Design details and processes.

V - Verify various processes and finally implement the same.

COMPARISON OF SIX SIGMA AND TOTAL QUALITY MANAGEMENT

Both Six Sigma and Total Quality Management are effective tools for quality management but a thin line of difference does exist between them. Although the methodologies and procedures involved in both the two appear quite similar but there are certain major differences.

Six-Sigma is a relatively newer concept than Total Quality Management but not exactly its replacement. The basic difference between Total Quality Management and Six Sigma is that TQM delivers superior quality manufactured goods whereas six sigma on the other hand results in better results. Total Quality management refers to continuous effort by employees to ensure

high quality products. The process of Six Sigma incorporates many small changes in the systems to ensure effective results and better customer satisfaction.

Total Quality Management involves designing and developing new systems and processes and ensures effective coordination among various departments. New Processes are developed based on various customer feedbacks and researches.

The main focus of Total quality management is to maintain existing quality standards whereas Six Sigma primarily focuses on making small necessary changes in the processes and systems to ensure high quality.

The process of Total quality management does reach to a saturation level after a certain period of time. After reaching the saturation stage, no further improvements in quality can be made. Six Sigma on the other hand seldom reaches the saturation stage by initiating a next level quality process.

The process of Total quality management involves improvement in existing policies and procedures to ensure high quality. **Six-Sigma focuses on improving quality by minimizing and eventually eliminating defects from the system**. The process of total Quality management ensures that every single member associated with the organization is working towards the improvement of existing processes, systems, services and work culture for long term quality products/services. Six Sigma, on the other hand focuses on first identifying and eventually removing various defects and obstacles which might come in the way of organization's success. In a layman's language total quality management emphasizes on improving the existing policies and making necessary changes in the systems to ensure superior quality products and services. Organizations practicing Six Sigma are focused on removing errors and defects to ensure high quality products.

Total Quality management is a less complicated process than Six Sigma. Six-Sigma involves specially trained individuals whereas total quality management does not require extensive training. The process of Six Sigma creates special levels for employees who are only eligible to implement the same. Employees trained for Six Sigma are often certified as "Green Belts" or "Black Belts" depending on their level of proficiency. Six-Sigma requires participation of only certified professionals whereas total quality management can be referred to a part time activity which does not require any special training. Six-Sigma can be implemented by dedicated and well trained professionals.

Six-Sigma is known to deliver better and effective results as compared to total quality management. The process of Six Sigma is based on customer feedbacks and is more accurate and result oriented. Customer feedbacks play an important role in Six Sigma. Experts predict that six sigma will outshine total quality management in due course of time.

QUALITY MANAGEMENT TOOLS

Quality Management tools help organization collect and analyze data for employees to easily understand and interpret information. Quality Management models require extensive planning and collecting relevant information about end-users. Customer feedbacks and expectations need to be carefully monitored and evaluated to deliver superior quality products.

Quality Management tools help employees identify the common problems which are occurring repeatedly and also their root causes. Quality Management tools play a crucial role in improving the quality of products and services. With the help of Quality Management tools employees can easily collect the data as well as organize the collected data which would further help in analyzing the same and eventually come to concrete solutions for better quality products.

Quality Management tools make the data easy to understand and enable employees to identify processes to rectify defects and find solutions to specific problems.

Following are the quality management tools:

- **Check List -** Check lists are useful in collecting data and information easily .Check list also helps employees to identify problems which prevent an organization to deliver quality products which would meet and exceed customer expectations. Check lists are nothing but a long list of identified problems which need to be addressed. Once you find a solution to a particular problem, tick it immediately. Employees refer to check list to understand whether the changes incorporated in the system have brought permanent improvement in the organization or not?
- **Pareto Chart -** The credit for Pareto Chart goes to Italian Economist - Wilfredo Pareto. Pareto Chart helps employees to identify the problems, prioritize them and also determine their frequency in the system. Pareto Chart often represented by both bars and a line graph identifies the most common causes of problems and the most frequently occurring defects. Pareto Chart records the reasons which lead to maximum customer complaints and eventually enables employees to formulate relevant strategies to rectify the most common defects.
- **The Cause and Effect Diagram -** Also referred to as "Fishbone Chart" (because of its shape which resembles the side view of a fish skeleton)and Ishikawa diagrams after its creator Kaoru Ishikawa, Cause and Effect Diagram records causes of a particular and specific problem .The cause and effect diagram plays a crucial role in identifying the root cause of a particular problem and also potential factors which give rise to a common problem at the workplace.
- **Histogram -** Histogram, introduced by Karl Pearson is nothing but a graphical representation showing intensity of a particular problem. Histogram helps identify the cause of problems in the system by the shape as well as width of the distribution.
- **Scatter Diagram -** Scatter Diagram is a quality management tool which helps to analyze relationship between two variables. In a scatter chart, data is represented as points, where each point denotes a value on the horizontal axis and vertical axis.

  Scatter Diagram shows many points which show a relation between two variables.

- **Graphs -** Graphs are the simplest and most commonly used quality management tools. Graphs help to identify whether processes and systems are as per the expected level or not and if not also record the level of deviation from the standard specifications.