Industrial Engineering Management

BASRA UNIVERSITY FOR OIL AND GAS – OIL AND GAS ENGINEERING COLLEGE

3rd YEAR BY: M.SC. ISMAEIL R. ALNAAB

Course Topics:

- Introduction and History
- Company, Organization, Foundation and Organizational Chart
- Facility Location and Layout Planning
- Marketing and Distribution
- Project Management, Planning, Operation and Control.
- Linear optimization
- Maintenance Management
- Total Quality Management
- QA/QC
- Financial Management
- Human Resources

Course Objectives:

The objectives of the industrial engineering and engineering management program are to produce students who:

- Contribute to the success of companies through effective problem solving.
- Design, develop, implement, and improve integrated systems that include people, materials, information, equipment, and environments
- Effectively manage business operations and project management teams
- Continue to develop holistically, including the personal and professional skills necessary to adapt to our changing societal, technological, and global environments
- Students who finish this course are expected to meet the challenges for modern professional practice; be able to adapt and solve the increasingly complex problems faced by industry; embrace innovation through intellectual diversity and creative problem solving; and continue to develop holistically as a learner to become leaders of tomorrow.

INTRODUCTION AND HISTORY:

Engineering management is a career that brings together the technological problem-solving ability of engineering and the organizational, administrative, legal and planning abilities of management in order to oversee the operational performance of complex engineering driven enterprises.

Industrial engineering is a branch of engineering which deals with the optimization of complex processes, systems or organizations. Industrial engineers work to eliminate waste of time, money, materials, man-hours, machine time, energy.

Industrial Engineers use specialized knowledge and skills in the mathematical, physical and social sciences, together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results obtained from systems and processes.

Depending on the sub-specialties involved, industrial engineering may also overlap with, operations research, systems engineering, manufacturing engineering, production engineering, supply chain engineering, management science, management engineering, financial engineering, ergonomics or human factors engineering, safety engineering, logistics engineering or others, depending on the viewpoint or motives of the user.

There are several industrial engineering principles followed in the manufacturing industry to ensure the effective flow of the systems, processes and operations. This includes Lean Manufacturing, Six Sigma, Information Systems, DMAIC and DMADV. These principles allow the creation of new systems, processes or situations for the useful coordination of labor, materials and machines and also improve the quality and productivity of systems, physical or social.

Lean manufacturing is a production process based on an ideology of maximizing productivity while simultaneously minimizing waste within a manufacturing operation. The lean principle sees waste is anything that doesn't add value that the customers are willing to pay for.

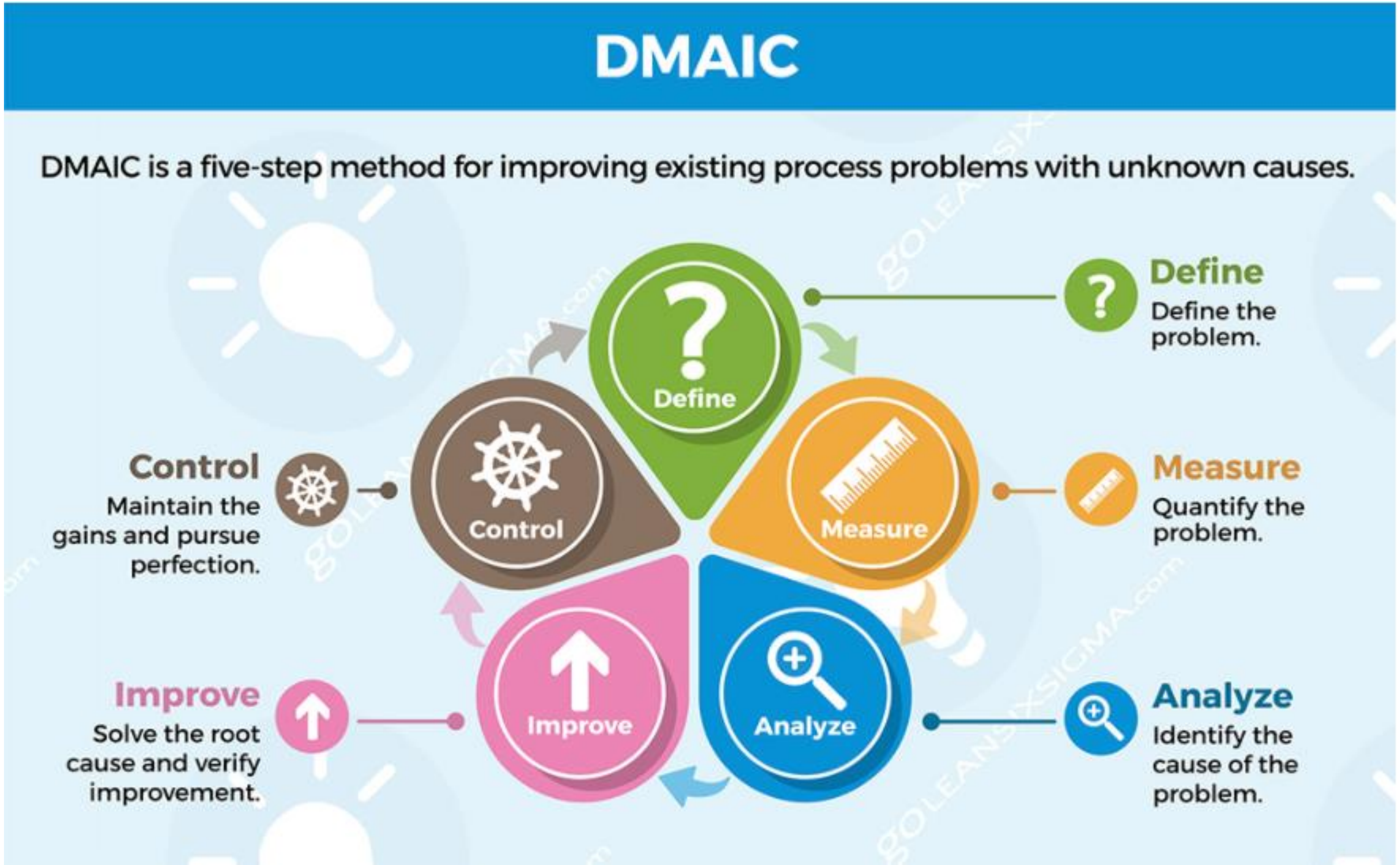
Six Sigma (6σ) is a set of techniques and tools for process improvement. It was introduced by American engineer Bill Smith while working at Motorola in 1986.

Information System (IS) is a formal, sociotechnical, organizational system designed to collect, process, store, and distribute information. From a sociotechnical perspective, information systems are composed by four components: task, people, structure (or roles), and technology.

DMAIC is used for projects aimed at improving an existing business process.
DMADV is used for projects aimed at creating new product or process designs.

The DMAIC project methodology has five phases:

- Define the system, the voice of the customer and their requirements, and the project goals, specifically.
- Measure key aspects of the current process and collect relevant data; calculate the "as-is" process capability.
- Analyze the data to investigate and verify cause and effect. Determine what the relationships are, and attempt to ensure that all factors have been considered. Seek out the root cause of the defect under investigation.
- Improve or optimize the current process based upon data analysis using techniques such as design of experiments or mistake proofing.
- Control the future state process to ensure that any deviations from the target are corrected before they result in defects. Implement control systems such as statistical process control, production boards, visual workplaces, and continuously monitor the process. This process is repeated until the desired quality level is obtained.

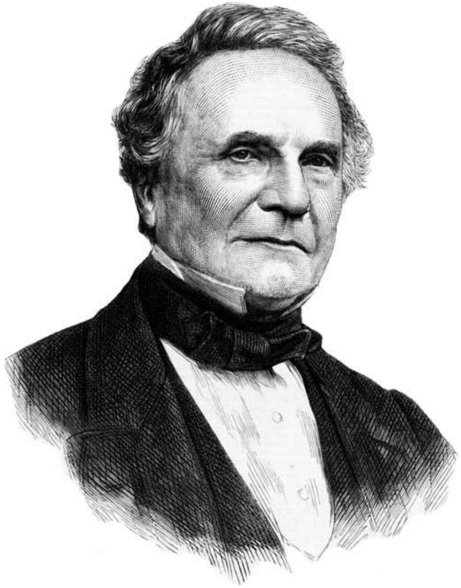

DMAIC
DMAIC is a five-step method for improving existing process problems with unknown causes.
Define
Define the problem.
Measure
Quantify the problem.
Analyze
Identify the cause of the problem.
Improve
Solve the root cause and verify improvement.
Control
Maintain the gains and pursue perfection.
Define
Measure
Analyze
Improve
Control

The DMADV

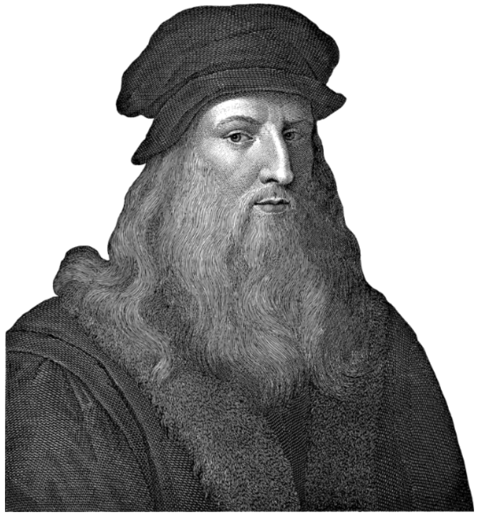
Also known as DFSS ("Design For Six Sigma"), the DMADV methodology's five phases are

- Define design goals that are consistent with customer demands and the enterprise strategy.
- Measure and identify CTQs (characteristics that are Critical To Quality), measure product capabilities, production process capability, and measure risks.
- Analyze to develop and design alternatives.
- Design an improved alternative, best suited per analysis in the previous step.
- Verify the design, set up pilot runs, implement the production process and hand it over to the process owner(s).

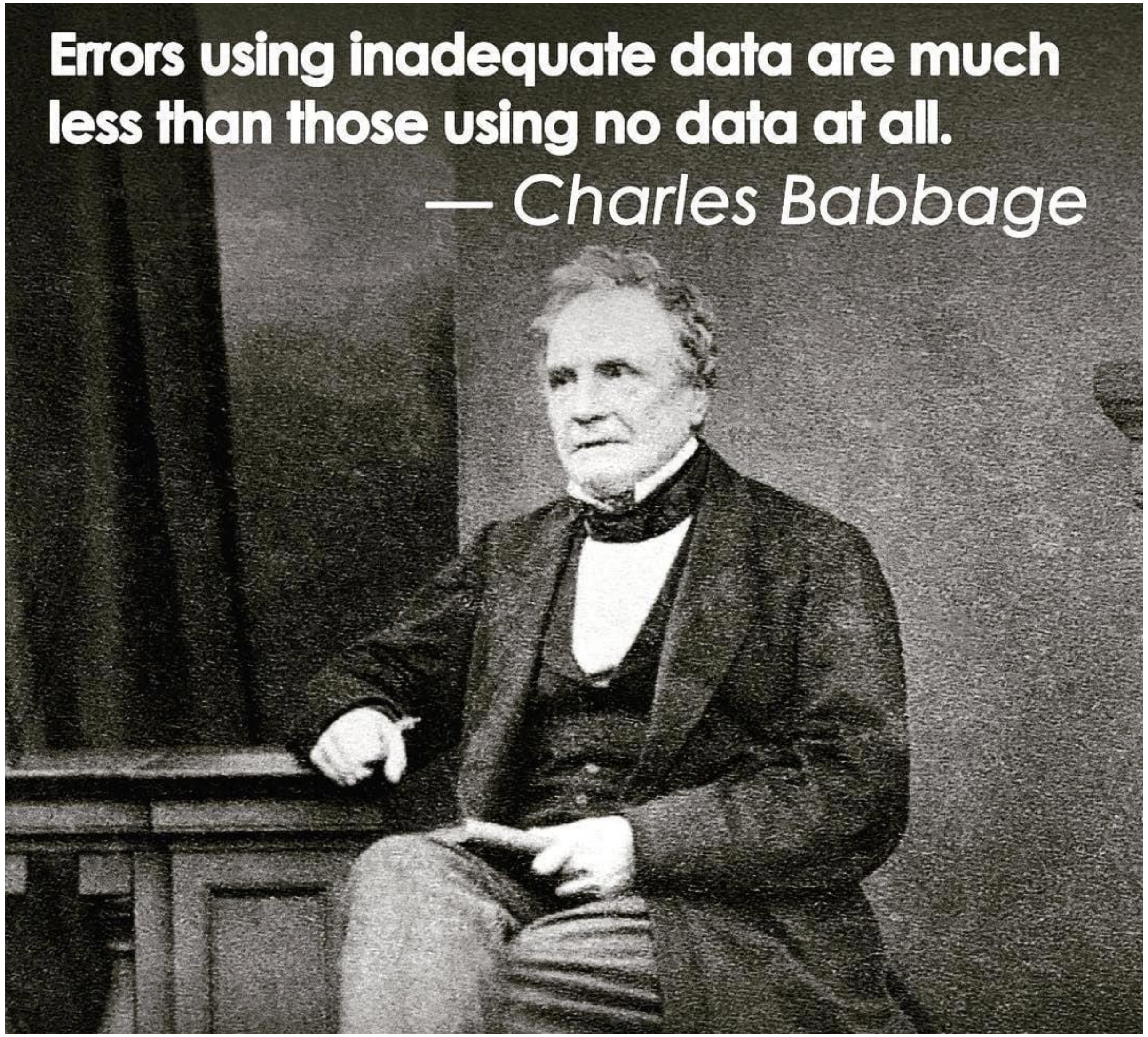
There is a general consensus among historians that the roots of the industrial engineering profession date back to the Industrial Revolution. The technologies that helped mechanize traditional manual operations in the textile industry including the flying shuttle, the spinning jenny, and perhaps most importantly the steam engine generated economies of scale that made mass production in centralized locations attractive for the first time. The concept of the production system had its genesis in the factories created by these innovations. It has also been suggested that perhaps Leonardo da Vinci was the first Industrial Engineer, because there is evidence that he applied science to the analysis of human work, by examining the rate at which a man could shovel dirt around the year 1500. Others also state that the IE profession grew from Charles Babbage's study of factory operations and specifically his work on the manufacture of straight pins in 1832 . However, it has been generally argued that these early efforts, while valuable, were merely observational and did not attempt to engineer the jobs studied or increase overall output.

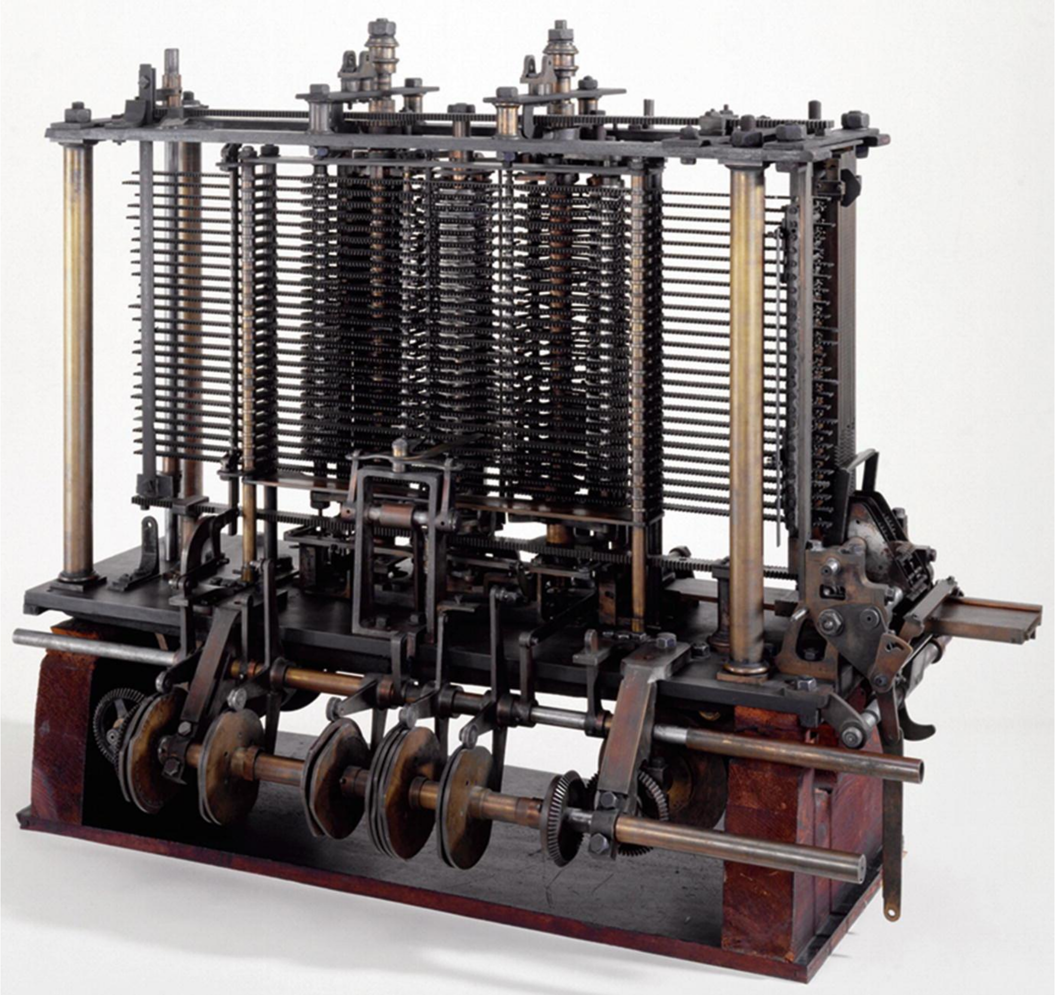


CHARLES BABBAGE



LEONARDO DA VINCI


Errors using inadequate data are much less than those using no data at all.
— Charles Babbage



A company, abbreviated as co., is a legal entity representing an association of people, whether natural, legal or a mixture of both, with a specific objective. Company members share a common purpose and unite to achieve specific, declared goals. Companies take various forms, such as:

- voluntary associations, which may include nonprofit organizations
- business entities, whose aim is generating profit
- financial entities and banks
- programs or educational institutions.

A company can be created as a legal person so that the company itself has limited liability as members perform or fail to discharge their duty according to the publicly declared incorporation, or published policy. When a company closes, it may need to be liquidated to avoid further legal obligations.
Companies may associate and collectively register themselves as new companies; the resulting entities are often known as corporate groups.

Organization: is a group of people working together in an organized manner to reach a particular goal called a product.

Organizations may also operate secretly or illegally in the case of secret societies, criminal organizations and resistance movements. And in some cases may have obstacles from other organizations, but what makes an organization an organization is not the paperwork that makes it official but to be an organization there must be four things:

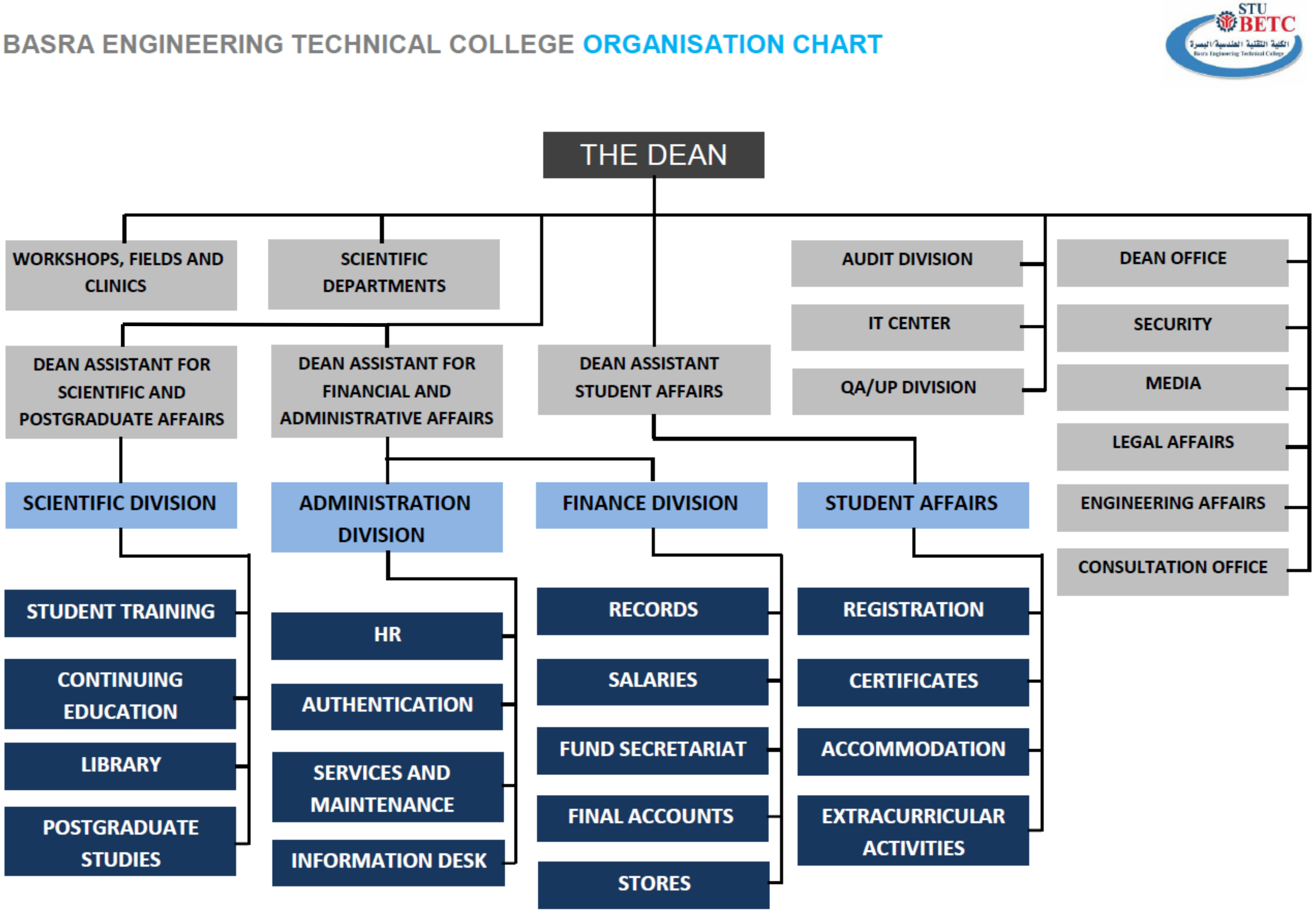
A goal in mind
A leader or committee making the decision
Action involved
Communication and members.

Foundation:

In the nonprofit sector, the term foundation has no precise meaning. The Council on Foundations defines a foundation as an entity that supports charitable activities by making grants to unrelated organizations or institutions or to individuals for scientific, educational, cultural, religious, or other charitable purposes. While foundations are often primarily engaged in grantmaking activities, some may engage in their own direct charitable activities or programs.

Organizational chart, also called Organizing Board, organigram, organogram, or organizational breakdown structure (OBS) is a diagram that shows the structure of an organization and the relationships and relative ranks of its parts and positions/jobs.

Without an Org. Board there is no group product, there is only a mob (large disorderly crowd)



الهيكل التنظيمي لكلية هندسة النفط والغاز
College of Oil and Gas Engineering
مجلس الكلية
عميد الكلية
مكتب العميد
القلم السرى
امانة مجلس الكلية
معاون العميد للشؤون الإدارية والمالية
وحدة شؤون المواطنين
شعبة ضمان الجودة والأداء الجامعي
الأقسام العلمية
الشعبة القانونية
شعبة الاعلام
معاون العميد للشؤون العلمية والدراسات العليا
وحدة الأداء الجامعي
وحدة ضمان الجودة
قسم الهندسة الكيميائية وتكرير النفط
قسم هندسة النفط والغاز
قسم هندسة البوليمرات والبتروكيمياويات
مكتب معاون العميد للشؤون الإدارية والمالية
وحدة الصادر والوارد
وحدة الافراد
وحدة الأضابير الشخصية
شعبة الموارد البشرية
وحدة الطباعة
وحدة الإحصاء
وحدة المتابعة
وحدة الهويات
وحدة الخدمات والصيانة
وحدة مخزن الكلية
مجانية التعليم
مكتب معاون العميد للشؤون العلمية والدراسات العليا
وحدة التدريب الصيفى
وحدة الحاسبة والانترنت
وحدة التأهيل والتوظيف والمتابعة
شعبة شؤون الطلبة
وحدة الوثائق
وحدة التسجيل
وحدة الارشاد النفسي والتوجيه التربوي
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Task Group:

Task groups are groups of individuals brought together to accomplish a specific action or produce a product. If you have participated in an educational planning meeting, been a member of a committee, attended a treatment team meeting, been elected to student government, or joined a social movement group, you have already experienced a task group in action.

Group A	Group B	Group C	Group D

Task No. 1 (First Week)

A group has to design and create a non particular thing from ice cream sticks.
All groups has to demonstrate their product in front of a judgement Commission.
The group that gets more votes from the judges is the winner.

- Facility Location and Layout Planning

Facility Location is the right location for the manufacturing facility, it will have sufficient access to the customers, workers, transportation, etc.

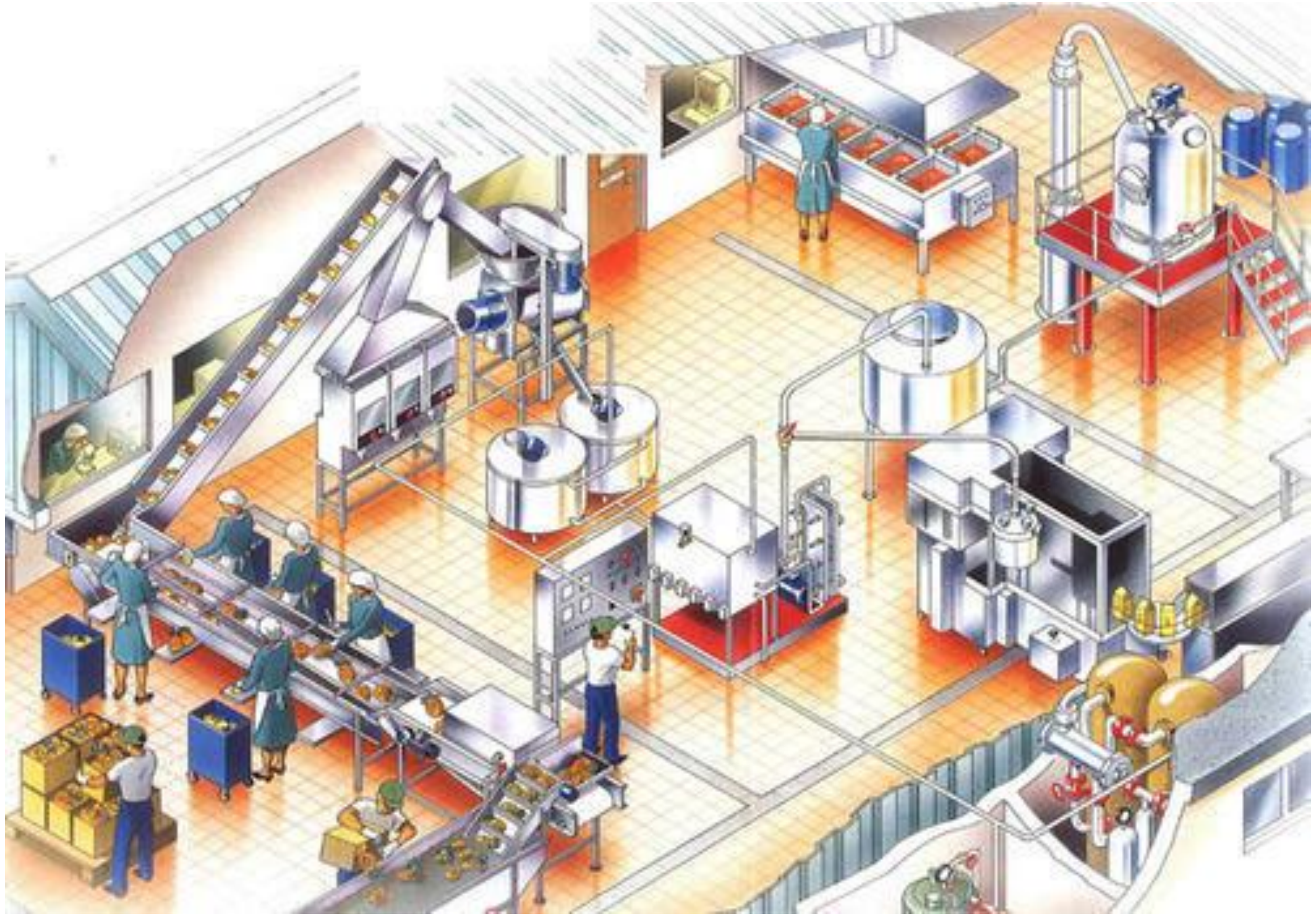
Facility location is a scientific process utilizing various techniques.

Facility location determination is a business critical strategic decision.

Overall objective of an organization is to satisfy and delight customers with its product and services. Therefore, for an organization it becomes important to have strategy formulated around its manufacturing unit.

A manufacturing unit is the place where all inputs such as raw material, equipment, skilled labors, etc. come together and manufacture products for customers.

One of the most critical factors determining the success of the manufacturing unit is the location.

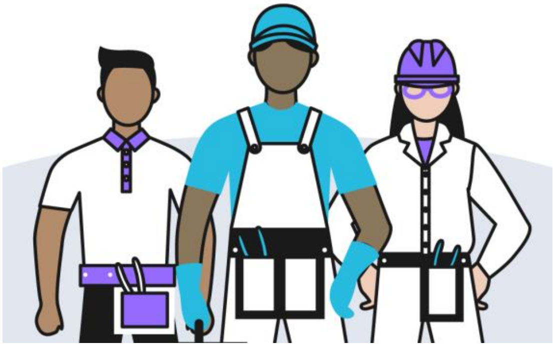


There are several factors, which determine the location of facility among them competition, cost and corresponding associated effects.

Location Selection Factors

For a company which operates in a **global environment;** cost, available infrastructure, labor skill, government policies and environment are very important factors.

A right location provides adequate access to customers, skilled labors, transportation, etc. A right location ensures success of the organization in current global competitive environment.



Errors in Location Selection

Facility location is critical for business continuity and success of the organization. So it is important to avoid mistakes while making selection for a location. Errors in selection can be divided into two broad categories behavioral and non-behavioral.

Behavioral errors are decision made by executives of the company where personal factors are considered before success of location, for example, movement of personal establishment from hometown to new location facility.

Non-behavioral errors include lack of proper investigative practice and analysis, ignoring critical factors and characteristics of the industry.

Location Strategy

The goal of an organization is customer delight for that it needs access to the customers at minimum possible cost. This is achieved by developing location strategy. Location strategy helps the company in determining product offering, market, demand forecast in different markets, best location to access customers and best manufacturing and service location.

Factors Influencing Facility Location

If the organization can configure the right location for the manufacturing facility, it will have sufficient access to the customers, workers, transportation, etc.

For commercial success, and competitive advantage following are the critical factors:

1. **Customer Proximity:** Facility locations are selected closer to the customer as to reduce transportation cost and decrease time in reaching the customer.
2. **Business Area:** Presence of other similar manufacturing units around makes business area conducive for facility establishment.
3. **Availability of Skill Labor:** Education, experience and skill of available labor are another important, which determines facility location.

4. **Free Trade Zone/Agreement:** Free-trade zones promote the establishment of manufacturing facility by providing incentives in custom duties and levies. On another hand free trade agreement is among countries providing an incentive to establish business, in particular, country.
5. **Environmental Policy:** In current globalized world pollution, control is very important, therefore understanding of environmental policy for the facility location is another critical factor.

6. **Suppliers:** Continuous and quality supply of the raw materials is another critical factor in determining the location of manufacturing facility.

Facility Layout - Objectives, Design and Types of Facility Layout

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 Objectives:

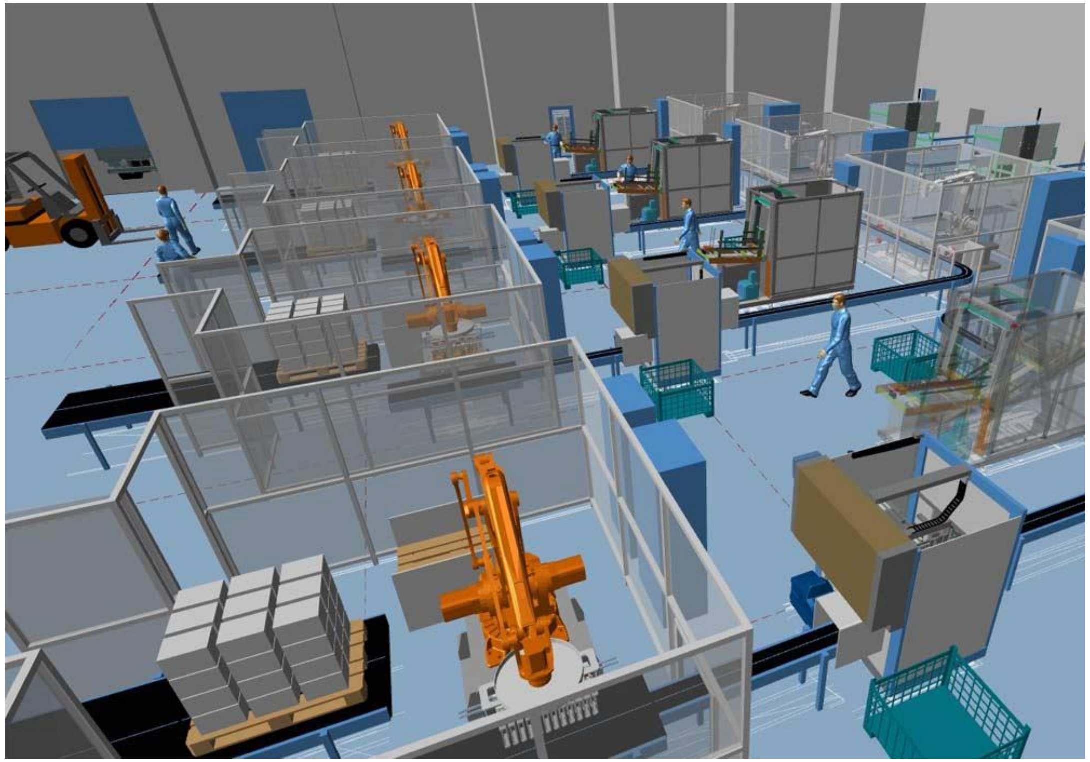
- To provide optimum space to organize equipment and facilitate movement of goods and to create safe and comfortable work environment.
- To promote order in production towards a single objective
- To reduce movement of workers, raw material and equipment
- To promote safety of plant as well as its workers
- 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.

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.

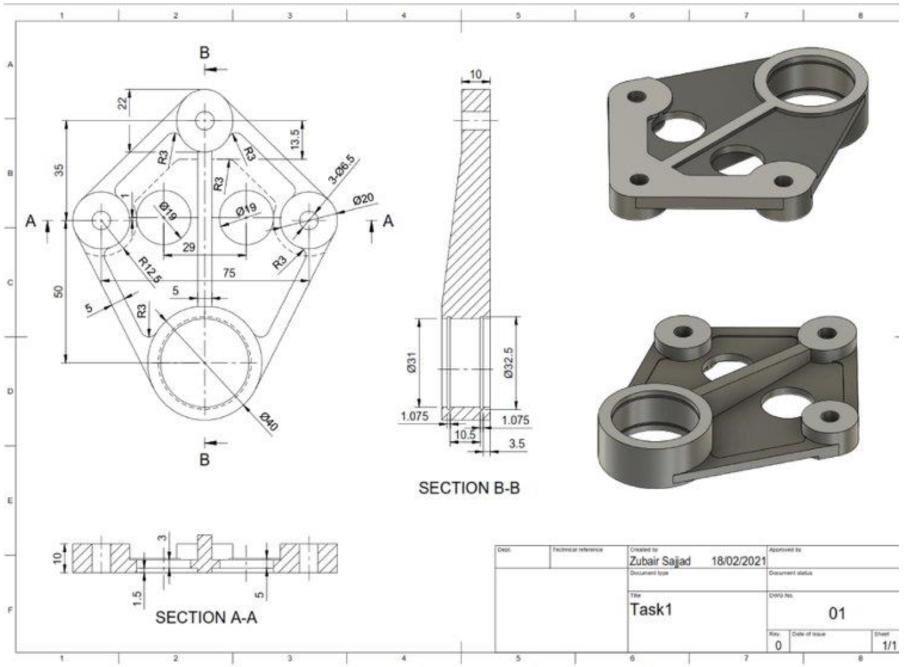
Space Utilization: Optimum space utilization reduces the time in material and people movement and promotes safety.

Capital: Capital investment should be minimal when finalizing different models of facility layout.

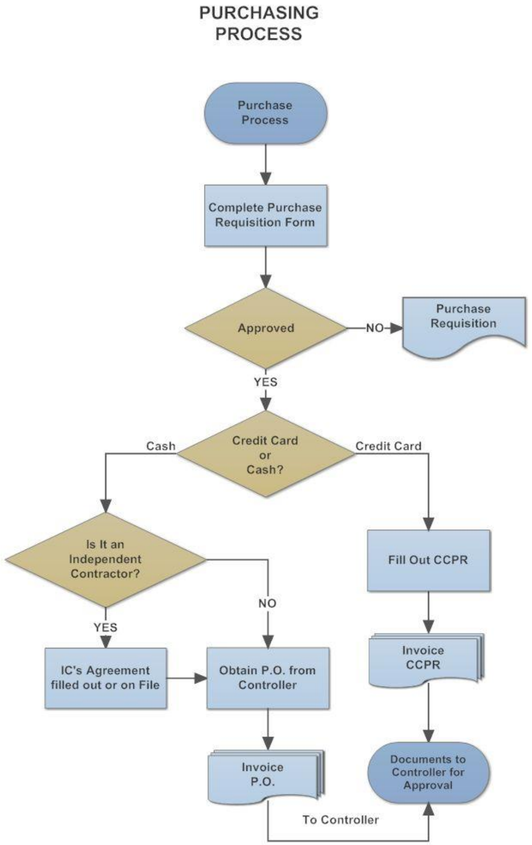
Design Layout Techniques:

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

- Two or Three Dimensional Templates: This technique utilizes development of a scaled-down model based on approved drawings.
- 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.
- Line Balancing: This kind of technique is used for assembly line.



2D or 3D Templates



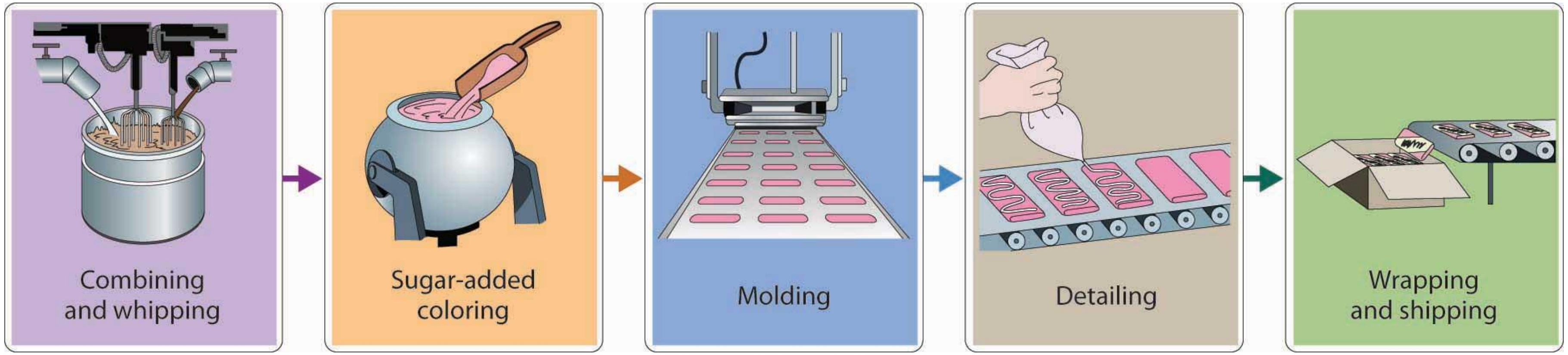
Sequence Analysis

Line Balancing

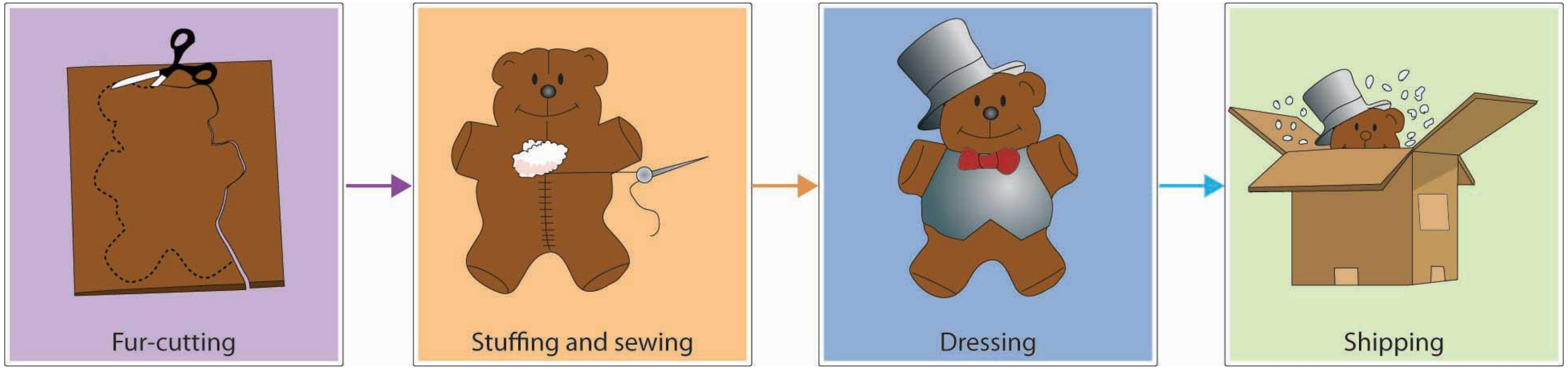
Types of Facility Layout:

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

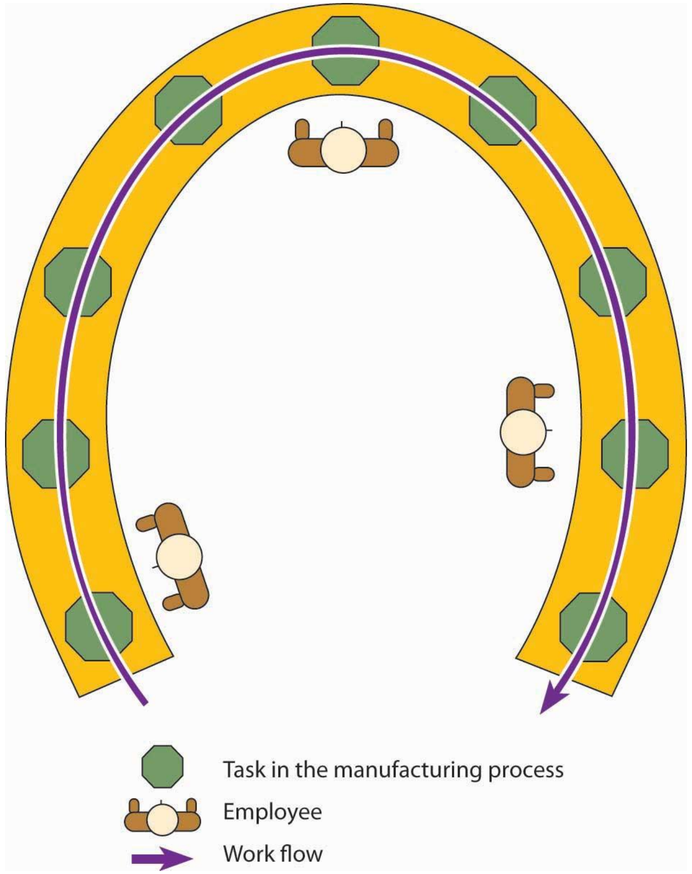
1. Line Layout (Product layout) (assembly line)
2. Functional Layout (Process layout) (Sequence layout)
3. Combined Layout (Product layout and Process layout together)
4. Fixed Position Layout (Product is fixed & Equipment moves around it)
5. Cellular Technology Layout (The goal of cellular manufacturing is to move as quickly as possible, make a wide variety of similar products, while making as little waste as possible).
6. Computerized Relative Allocation of Facility Technique



Line Layout (Product layout) (Assembly line)



Functional Layout (Process layout) (Sequence layout)



Cellular Layout

Fixed Position Layout

- Marketing and Distribution

A channel of distribution *comprises a set of institutions which perform all of the activities utilized to move a product and its title from production to consumption*

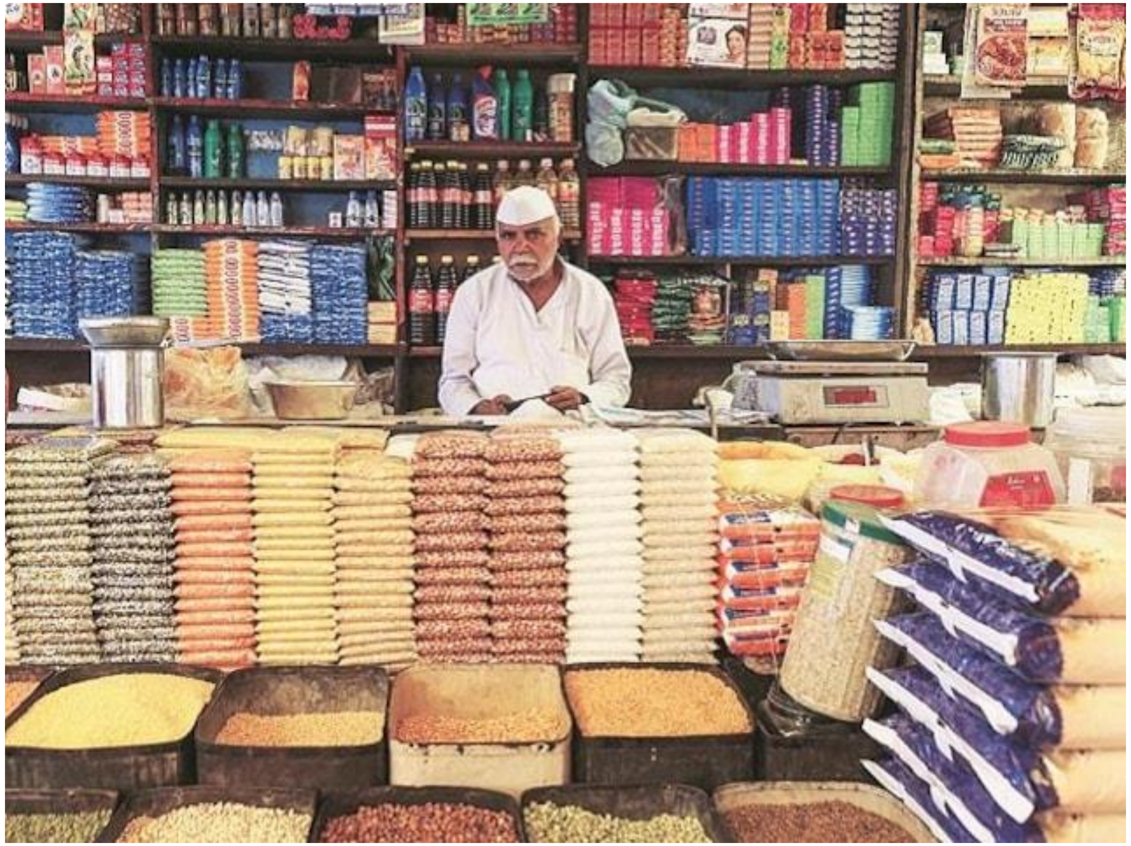
Bucklin - *Theory of Distribution Channel Structure*

- **Tasks of Intermediaries - Wholesalers**

1. Break down ‘bulk’
2. Buys from producers and sell small quantities to retailers
3. Provides storage facilities
4. Reduces contact cost between producer and consumer
5. Wholesaler takes some of the marketing responsibility e.g sales force, promotions

- **Tasks of Intermediaries - Retailer**

1. Much stronger personal relationship with the consumer
2. Hold a variety of products
3. Offer consumers credit
4. Promote and merchandise products
5. Price the final product
6. Build retailer ‘brand’ in the high street



What is an agent?

An agent is an intermediary involved in making a contract between the principal (supplier) and the principal's customer. Where goods are being sold, there are two kinds of agent; a sales agent and a marketing agent.

A sales agent has the authority to enter into agreements with the customer on the supplier's behalf. The agent can therefore bind the supplier to a contractual agreement.

A marketing agent, unlike a sales agent, does not have authority to bind the supplier, but can market and promote the supplier's product to prospective customers. When a customer wishes to make a purchase it is the supplier who completes the contract.

Agents are paid commission on the sales they make, usually on a percentage basis.

What is a distributor?

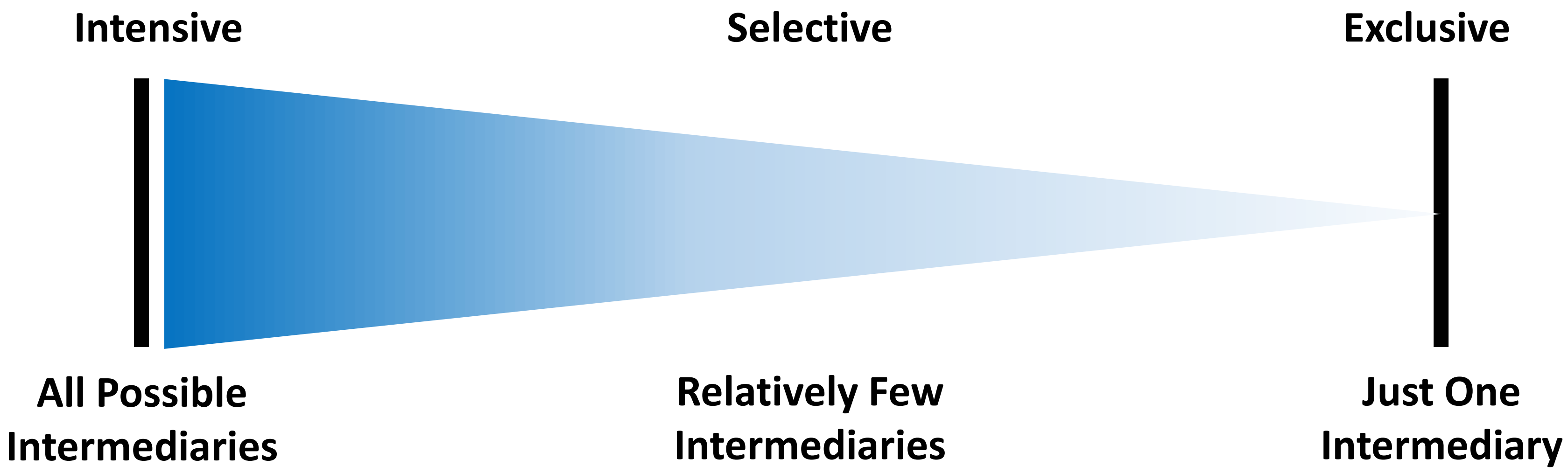
Unlike agents, distributors purchase products from the supplier and then resell them to customers in a particular territory on their own account, thereby taking control of pricing and the ensuing profit.

Types of Distributions:

- **Intensive Distribution:** the use of all suitable outlets to sell a product.
- **Selective Distribution:** a limited number of outlets in a given geographical area are used to sell the product.
- **Exclusive Distribution:** protected territories for distribution of a product in a given geographic area; business maintains tight control over a product.
- **Integrated Distribution:** Manufacturer acts as wholesaler and retailer for its own products.
- **Dual distribution:** A manufacturer may sell its products through multiple outlets at the same time: Toll-free phone system, Company website and Multiple retailers.

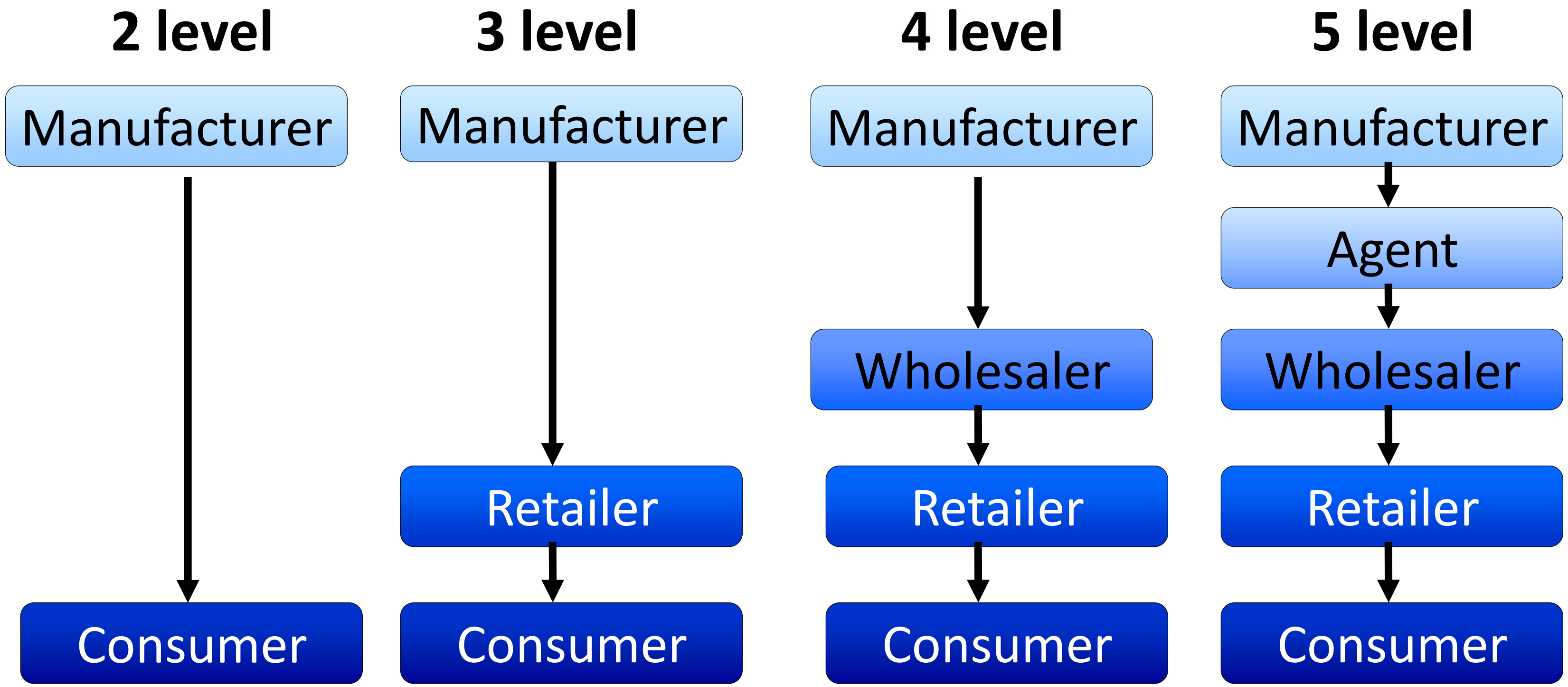
Intensity of Channel Structure

Channel intensity: the number of intermediaries at each level of the marketing channel.



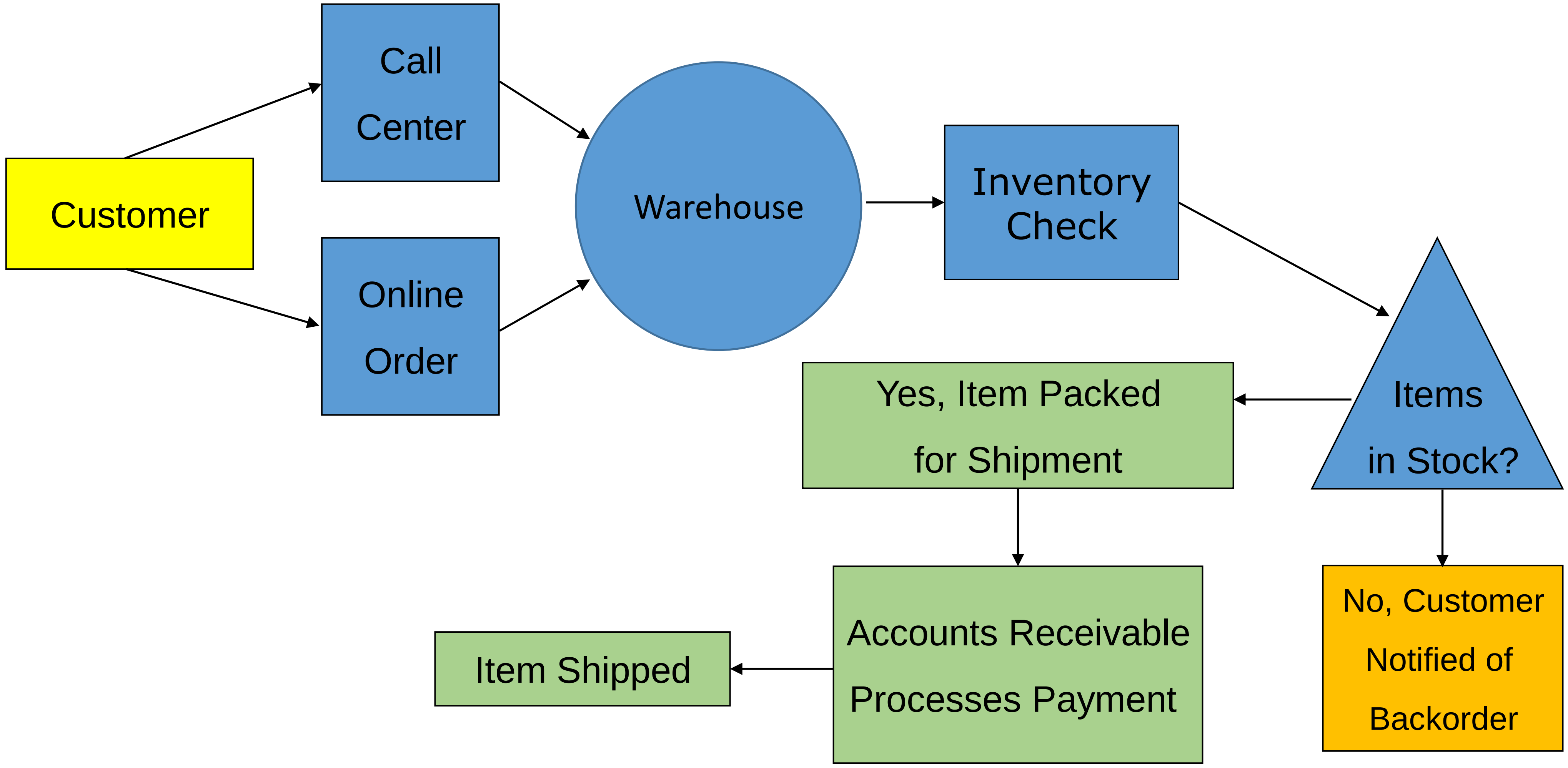
- **Channel design/structure:** form or shape that a marketing channel takes to perform the tasks necessary to make products available to consumers.

Channel length = Number of levels in a distribution channel



- In general, the shorter the channel structure, the higher the degree of control, and vice versa.
- The lower the intensity of distribution, the higher the degree of control, and vice versa.

- Actions to Facilitate Order Processing



- Use of Technology in Distribution

1. e-commerce: Products are sold to customers and industrial buyers through the Internet.
2. Satellite tracking, a dispatcher has current knowledge of a delivery truck's location and destination. Examples: (DHL and UPS)

How it works:

A. Bar coding on package
B. Package scanned at transition points in distribution chain
C. Customer uses internet to follow package along distribution chain; e-mail may be used
D. Global distribution: in some countries the postal service is not reliable; package tracking facilitates global trade

- Project Management, Planning, Operation and Control.

Project management: is the process of leading the work of a team to achieve all project goals within the given constraints.

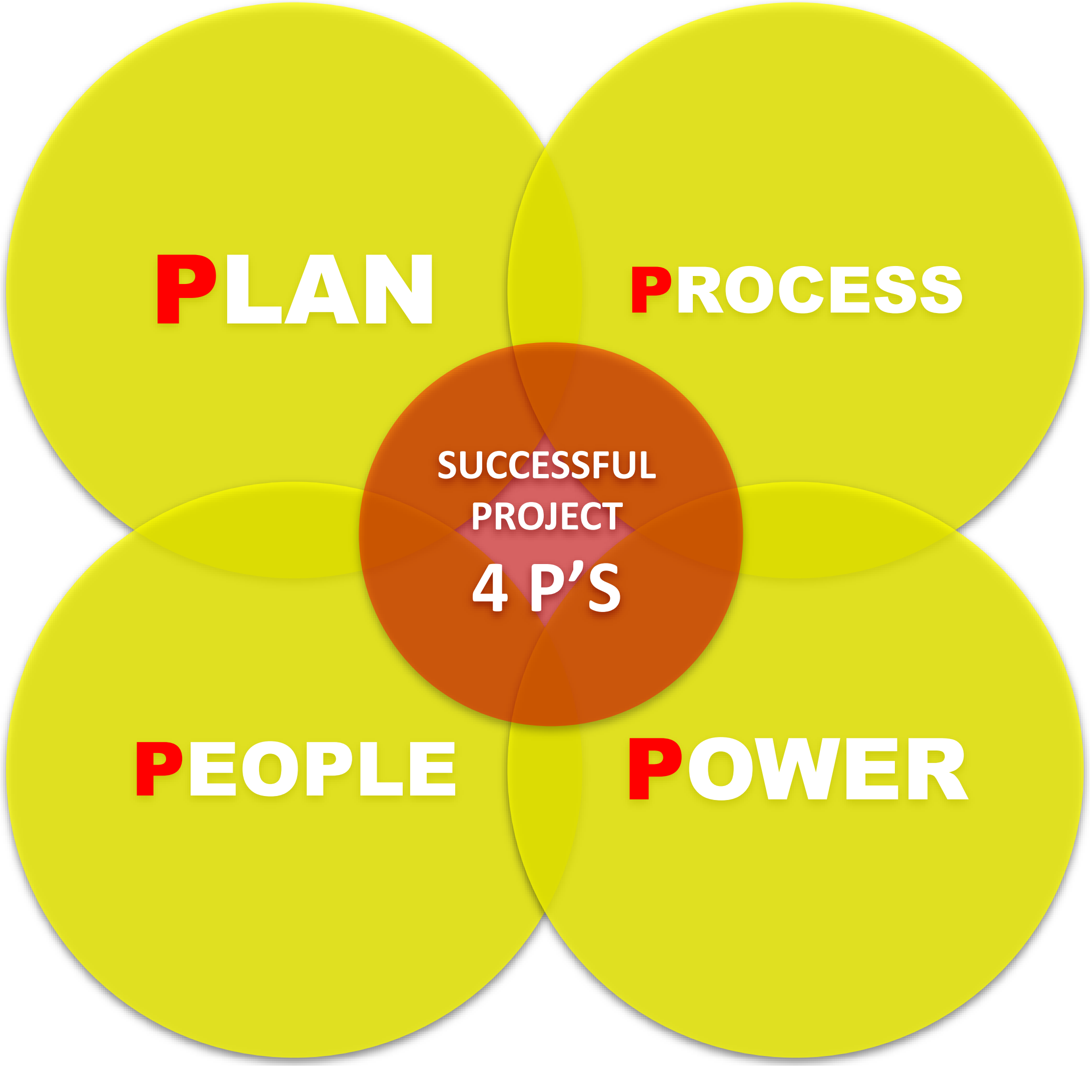
The primary constraints are: scope, time, and budget.

The **secondary challenge is:** to optimize the allocation of necessary inputs and apply them to meet pre-defined objectives.

The objective of project management is to produce a complete project which complies with the client's objectives.

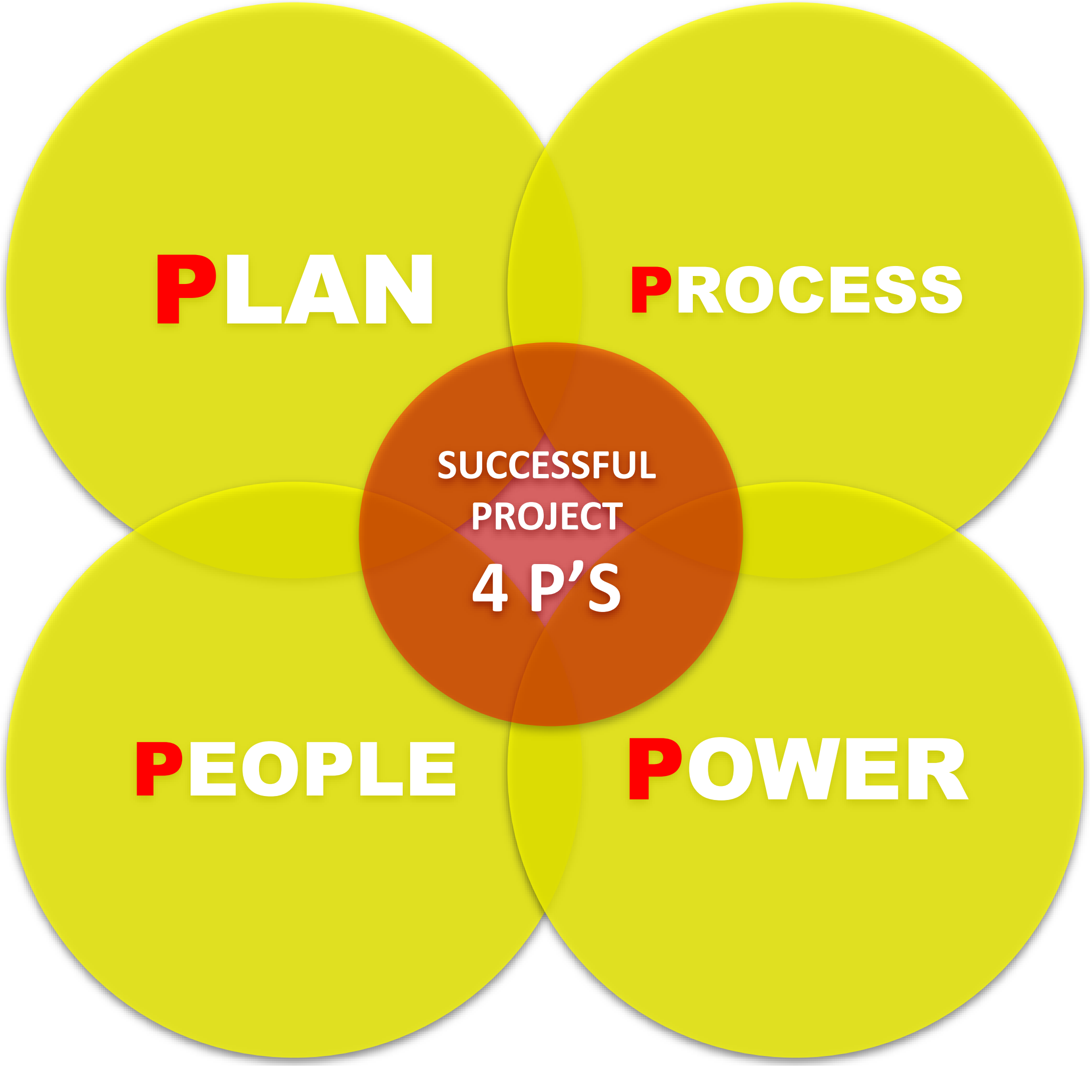
A 2017 study suggested that the success of any project depends on how well four key aspects are aligned with the contextual dynamics affecting the project, these are referred to as the four P's.

- Plan: The planning and forecasting activities.
- Process: The overall approach to all activities and project governance.



- People: Including dynamics of how they collaborate and communicate.
- Power: Lines of authority, decision-makers, organograms, policies for implementation and the like.

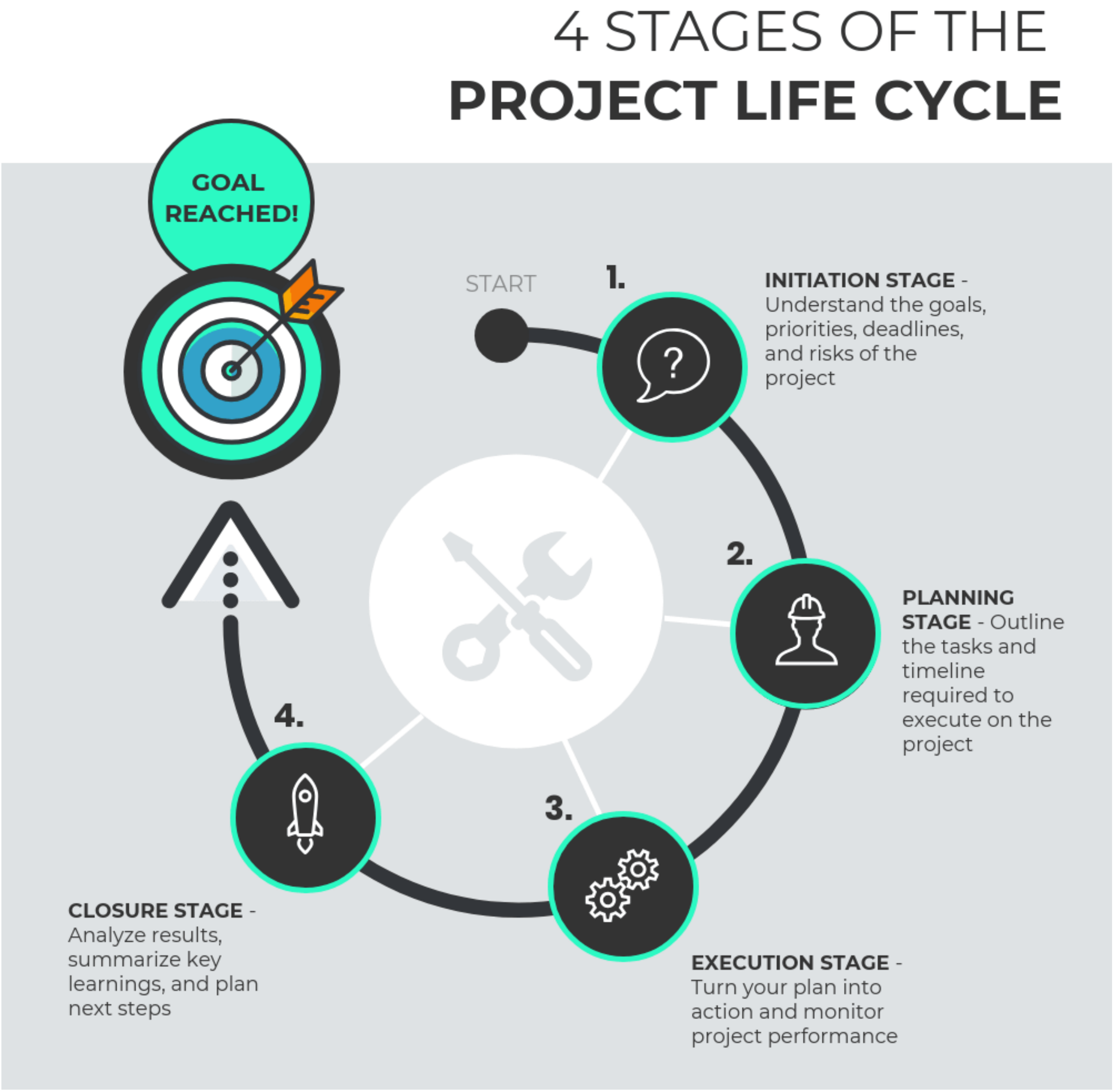
Aim & Expectations: What are the aims & expectations of the project.



- Project Lifecycle:

There are five phases to a project lifecycle; known as process groups. Each process group represent a series of inter-related processes to manage the work through a series of distinct steps to be completed. This type of project approach is often referred to as "traditional" or "waterfall".

The five process groups are: Initiating, Planning, Executing Monitoring and Controlling and Closing



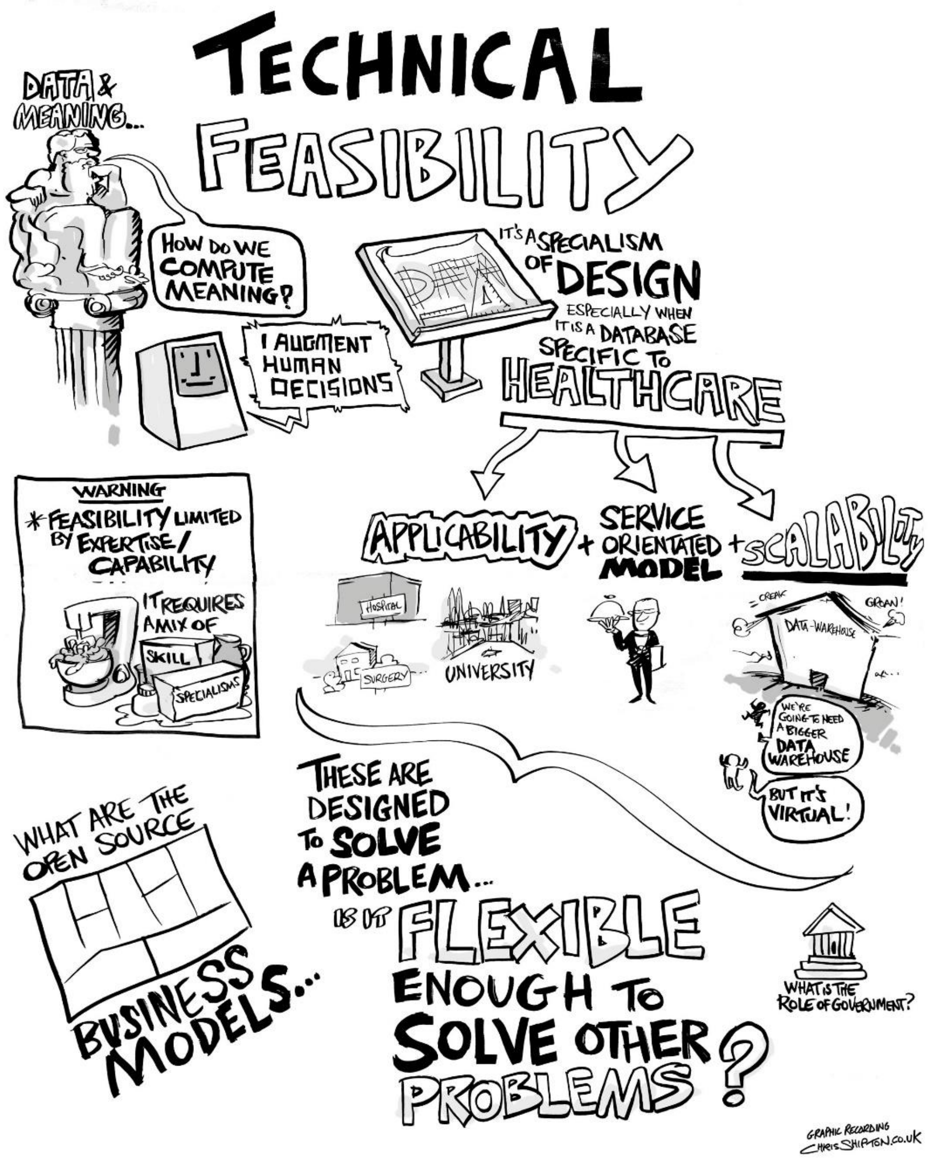
- Types of Feasibility Study

A feasibility analysis evaluates the project's potential for success; therefore, perceived objectivity is an essential factor in the credibility of the study for potential investors and lending institutions.

1. Technical Feasibility
2. Economic Feasibility
3. Legal Feasibility
4. Operational Feasibility
5. Scheduling Feasibility

1. Technical Feasibility

This assessment focuses on the technical resources available to the organization. It helps organizations determine whether the technical resources meet capacity and whether the technical team is capable of converting the ideas into working systems. Technical feasibility also involves the evaluation of the hardware, software, and other technical requirements of the proposed system. As an exaggerated example, an organization wouldn't want to try to put Star Trek's transporters in their building—currently, this project is not technically feasible.



2. Economic Feasibility

This assessment typically involves a cost/ benefits analysis of the project, helping organizations determine the viability, cost, and benefits associated with a project before financial resources are allocated. It also serves as an independent project assessment and enhances project credibility—helping decision-makers determine the positive economic benefits to the organization that the proposed project will provide.

3. Legal Feasibility

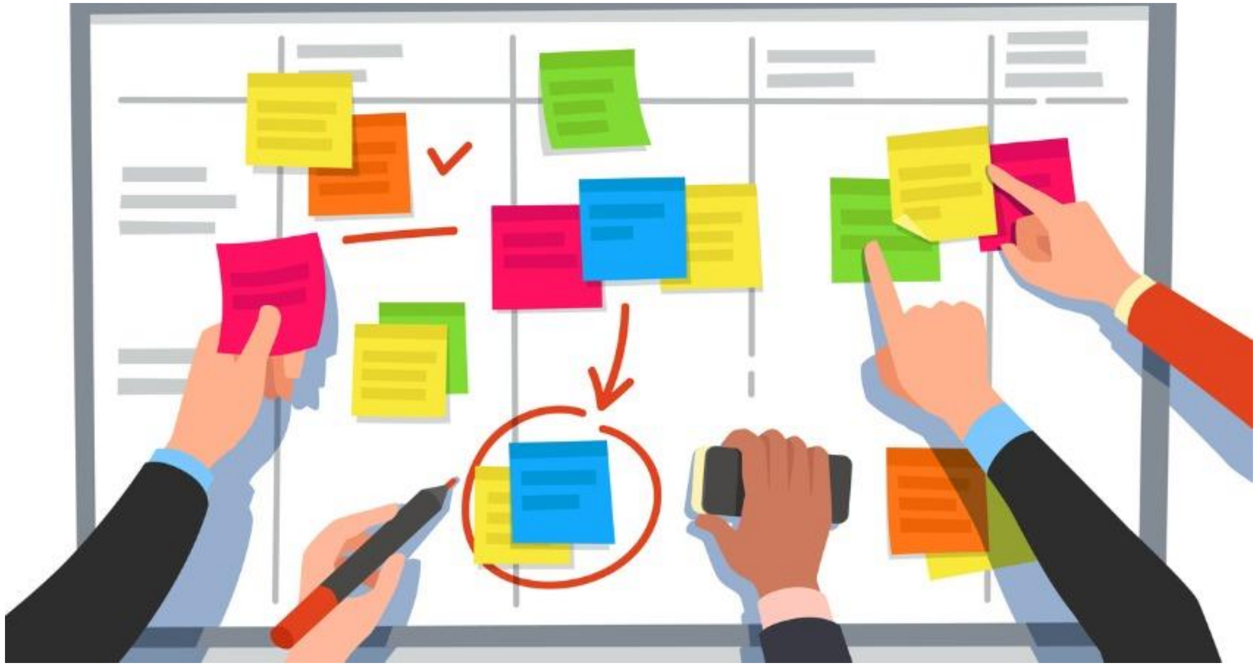
This assessment investigates whether any aspect of the proposed project conflicts with legal requirements like zoning laws, data protection acts or social media laws. Let's say an organization wants to construct a new office building in a specific location. A feasibility study might reveal the organization's ideal location isn't zoned for that type of business. That organization has just saved considerable time and effort by learning that their project was not feasible right from the beginning.

4. Operational Feasibility

This assessment involves undertaking a study to analyze and determine whether—and how well—the organization's needs can be met by completing the project. Operational feasibility studies also examine how a project plan satisfies the requirements identified in the requirements analysis phase of system development.

5. Scheduling Feasibility

This assessment is the most important for project success; after all, a project will fail if not completed on time. In scheduling feasibility, an organization estimates how much time the project will take to complete.



- **Feasibility Study:**

1. **Invested capital** , includes: (The cost of production machines and equipment, Spear parts and backup tools, Buildings of all kinds)

2. **Working capital** , includes: (The cost of raw, auxiliary and supplementary materials necessary for manufacturing operations, Manpower wages)

3. **Total cost of production** $= \boldsymbol{Variable\ costs} + \mathbf{Fixed\ Costs}$

- Variable costs are expenses that change with production volume; these costs rise when production increases and fall when it decreases. (utilities, Employees salary, direct labor, raw materials, and commissions).
- Fixed costs do not fluctuate with production volume; these costs remain the same whether there is zero production or running at full capacity. (Annihilations and maintenance of Machines, buildings and equipment, Rent and leased equipment).

4. Annual Profit = *Total Sales Value - Total cost of production*

5. Total added value = *Wages and guarantee + Annihilations (extermination) + Interest + Insurance + profits*

- *Net added value = Total added value - Annihilations*

6. The percentage of profitability of the project $= \frac{output}{input} = \frac{Annual\ Profit}{Invested\ capital} * 100\%$

7. Break-even point size $= \frac{Fixed\ costs}{Unit\ price - variable\ costs\ per\ unit}$

8. Break-even point value $= \dfrac{Fixed\ costs}{1 - \dfrac{variable\ costs}{anual\ Sales\ value}}$

9. Percentage of safety limit $= \dfrac{Actual\ Sales - Break{-}even\ Point\ Value}{Actual\ Sales} * 100\%$

10. Project shutdown time $= \dfrac{Invested\ capital}{Annual\ Profit + Annihilations}$

A project is considered as a profitable project or (Economically feasible) if:

- The percentage of profitability of the project >25%
- Project shutdown time is less than 4 years

Example:

A cake factory produces 100 high quality cake pieces per day. The selling price of one cake equals to 15 $. Given the following factory data table (1), drive a full Economic Feasibility study for this factory and its production. (240 working days in a year)

Invested capital		
Name	Price	
Grinding Machines	1000 $	8900 $
Separation Machines	800 $	
Mixing Machines	1500 $	
Motors and Belts	3000 $	
Nozzles and Valves	500 $	
Cake Equipment	500 $	
Cake Molds	300 $	
Decoration Molds	300 $	
Spear Parts	1000 $	
Buildings and Stores	60,000$	70,000 $
Selling area	10,000 $	
TOTAL	78,900 $	

Working Capital	
Name	Price
Raw Materials Flour, eggs, sugar, cooking oil, baking soda, cake mix, flavors, fruits, etc.	12,000 $
Annual Salaries of 20 employees	120,000 $
Industrial expenses Water, electricity, lubricating oil and diesel	5000 $
TOTAL	137,000

Total cost of production

Variable Costs	
Name	Price
Raw Materials	12,000 $
Industrial expenses	5000 $
TOTAL	17,000

Fixed Costs		
Name	Percentage	Price
Annihilations of Machines and tools	10%	890 $
Maintenance of Machines and tools	5%	445 $
Annihilations of Buildings	5%	3500 $
Maintenance of Buildings	2%	1400 $
Guarantees and Insurances of Machines and Tools	1%	89 $
Annual Salaries		120,000 $
TOTAL		126,324 $

$$\text{Total cost of production} = \mathit{Variable\ costs} + \text{Fixed Costs} = 17{,}000 + 126{,}324 = 143{,}324$$

Annual Profit = *Total Sales Value - Total cost of production*

$$Unit\ price\ =\ 15\ \$$$
$$Total\ Sales\ Value\ =\ 15\ \$\ *100*240=360{,}000\ \$$$
$$Unit\ Production\ Price=\frac{Total\ cost\ of\ Production}{Number\ of\ production\ Units}=\frac{143{,}324}{24{,}000}=6\ \$$$

Annual Profit = $360{,}000\ \$ - 143{,}324\ \$ = 216{,}676\ \$$

Total added value = Wages and guarantee + Annihilations (extermination) + Interest + Insurance + profits

Total added value = 120,000 + 3500 + 890 + 89 + 216,676 = 341,155

Net added value = Total added value – Annihilations = 120,000 + 89 + 216,676 = 336,765

The percentage of profitability of the project $= \frac{output}{input} = \frac{Annual\ Profit}{Invested\ capital} * 100\%$

$$= \frac{216{,}676\ \$}{78{,}900\ \$} * 100\% = 275\ \%$$

Break-even point size (quantity) $= \frac{Fixed\ costs}{Unit\ price - variable\ costs\ per\ unit} = \frac{126{,}324}{15 - \frac{17{,}000}{24{,}000}} = 8839$

Break-even point value $= \frac{Fixed\ costs}{1 - \frac{variable\ costs}{anual\ Sales\ value}} = \frac{126{,}324}{1 - \frac{17{,}000}{360{,}000}} = 132585$

Percentage of safety limit $= \frac{Actual\ Sales - Break{-}even\ Point\ Value}{Actual\ Sales} * 100\% =$

$$\frac{360{,}000 - 132585}{360{,}000} * 100\% = 63\ \%$$

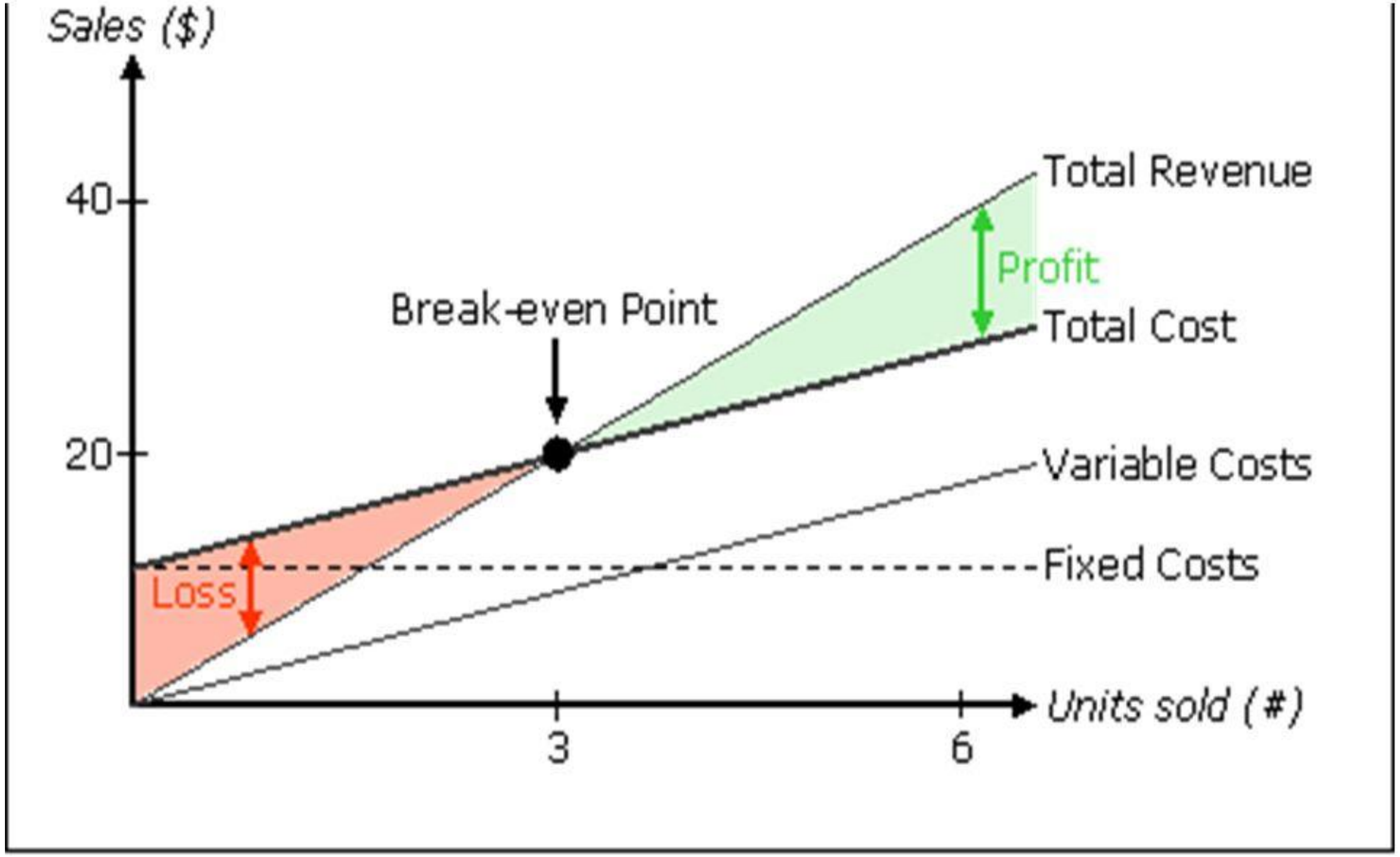
Project shutdown time $= \frac{Invested\ capital}{Annual\ Profit + Annihilations} = \frac{78{,}900}{216{,}676 + 3500 + 890} = 0.36$

Break-even analysis example:

Sara has dreams of opening a cupcake store. She does a break-even analysis to determine how many cupcakes she'll have to sell to break even on her investment. She's done the math, so she knows her fixed costs for one year are $10,000 and her variable cost per unit is $.50. She's done a competitor study and some other calculations and determined her unit price to be $6.00.

$10,000 / ($6 – $0.50) **= 1,819 cupcakes that Sara must sell in one year to break even**

Break Even Analysis



Example:

Company Bag Ltd. produces and sells the bags in the market and wants to conduct the break-even analysis of its business. The accountant in charge of the company determined that the fixed cost of the company consisting of salaries of the employees, rent cost, property tax, etc. will remain the same at $ 1,000,000. The variable cost, which is associated with the production of one unit of the bag, will come to $ 20. The bag is sold in the market at a premium price of $ 120. Prepare the break-even chart for Company Bag Ltd.

Solution:

Given,

Fixed Cost: $ 1,000,000

Variable cost: $ 20 per unit

Sales price: $ 120 per unit

Contribution per unit = Sales price per unit – Variable cost per unit

Contribution per unit = $ 120 – $ 20

Contribution per unit = $ 100

Given,
Fixed Cost: $ 1,000,000
Variable cost: $ 20 per unit
Sales price: $ 120 per unit
Contribution per unit = Sales price per unit – Variable cost per unit
Contribution per unit = $ 120 – $ 20
Contribution per unit = $ 100

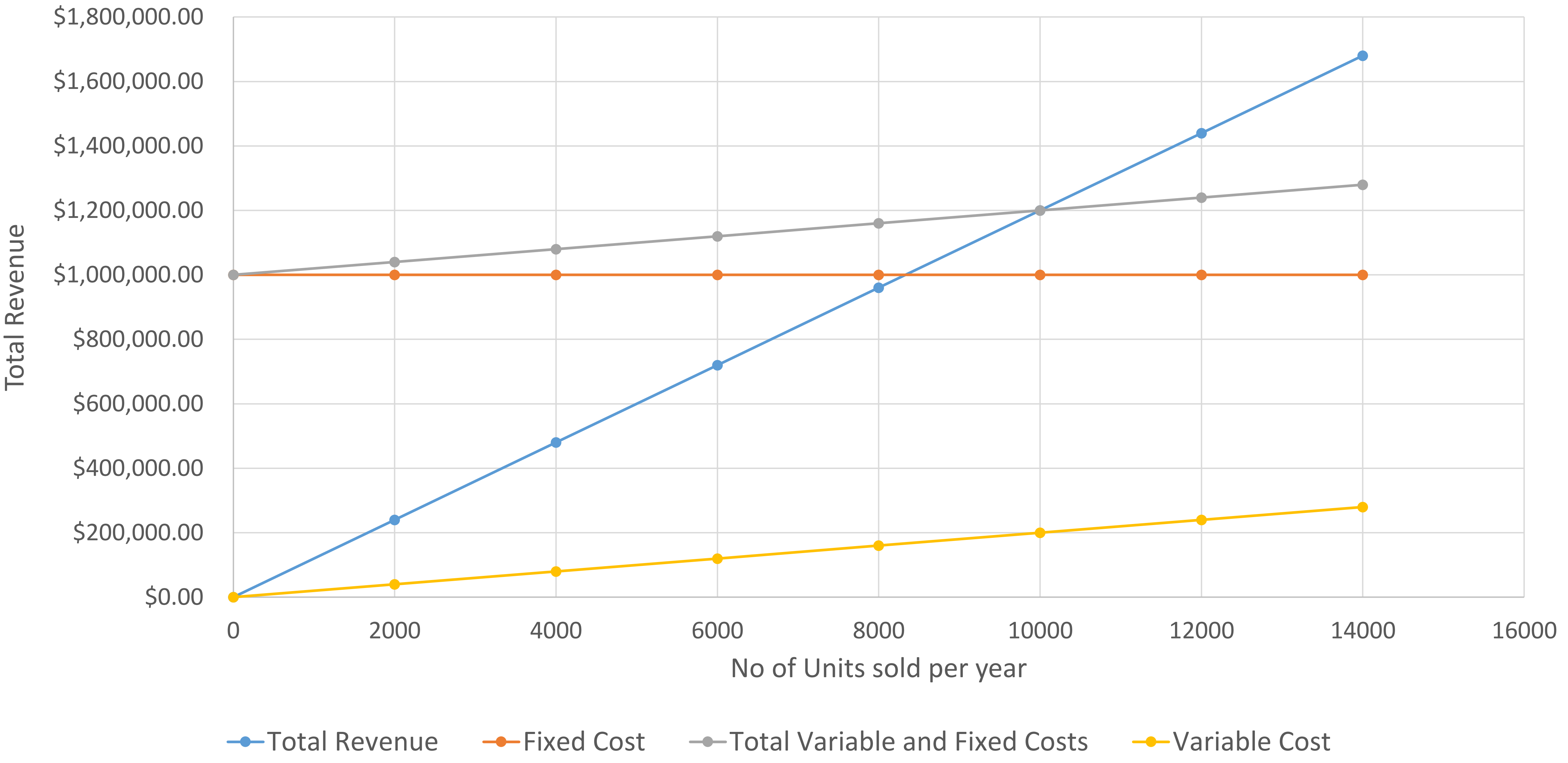
Break-even point size (quantity) $= \frac{Fixed\ costs}{Unit\ price - variable\ costs\ per\ unit} = \frac{1{,}000{,}000}{120-20} = 10{,}000\ unit\ per\ year$

It shows that the company Bag Ltd. would be required to sell the 10,000 units of bags to achieve the break-even at the given fixed cost, selling price, and the variable cost of the bag.

Graphical Representation of Break-Even Chart

Calculation of Different Costs for Bag Ltd for Different Number of Units Sold

No of Units sold per year	Fixed Cost	Total Variable Cost	Total Cost (Variable + Fixed)	Total Revenue
0	1,000,000.00$	0.00$	1,000,000.00$	0.00$
2000	1,000,000.00$	40,000.00$	1,040,000.00$	240,000.00$
4000	1,000,000.00$	80,000.00$	1,080,000.00$	480,000.00$
6000	1,000,000.00$	120,000.00$	1,120,000.00$	720,000.00$
8000	1,000,000.00$	160,000.00$	1,160,000.00$	960,000.00$
10000	1,000,000.00$	200,000.00$	1,200,000.00$	1,200,000.00$
12000	1,000,000.00$	240,000.00$	1,240,000.00$	1,440,000.00$
14000	1,000,000.00$	280,000.00$	1,280,000.00$	1,680,000.00$


$1,800,000.00
$1,600,000.00
$1,400,000.00
$1,200,000.00
$1,000,000.00
$800,000.00
$600,000.00
$400,000.00
$200,000.00
$0.00
Total Revenue
0
2000
4000
6000
8000
10000
12000
14000
16000
No of Units sold per year
Total Revenue
Fixed Cost
Total Variable and Fixed Costs
Variable Cost