



# **MANUFACTURING SYSTEM**

## **Vol. 1**



**Noorazian Binti Mohd Arshad**  
**Nur Hazwani Binti Nasruddin**

Diploma in Mechanical  
Engineering(Manufacturing)  
Mechanical Engineering Department  
Polytechnic Port Dickson

**MANUFACTURING SYSTEM  
VOL. 1**

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

e ISBN 978-967-2897-98-9



Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

A catalogue record for this book is available  
from the National Library of Malaysia

eISBN 978-967-2897-98-9

**PUBLISHED BY:**

Politeknik Port Dickson  
KM14, Jalan Pantai, 71050 Si Rusa  
Port Dickson, Negeri Sembilan

**SEPTEMBER 2023**

**Copyright** Each part of this publication may not be reproduced or distributed in any forms by any means or retrieval system without prior written permission.

# ACKNOWLEDGEMENT

## **PATRON**

Mej (K) Dr. Ishak bin Mohamad  
Director, Politeknik Port Dickson

## **ADVISORS**

Abdul Rahim bin Ibrahim  
Deputy Director (Academic), Politeknik Port Dickson  
Khairun Syatirin bin Md Salleh  
Head of Mechanical Engineering Department, Politeknik Port Dickson

## **EDITOR**

Nor Hazlina binti Amon  
Mechanical Engineering department, Politeknik Port Dickson

## **FACILITATORS**


Che Azlina binti Che Norohoseni  
Zuliana binti Zainal Abidin  
Hairul Azam bin Mohd Mokhtar

## **WRITERS**

Noorazian Binti Mohd Arshad  
Nur Hazwani binti Nasruddin

We would like to convey our utmost gratitude to the Department of Polytechnic and Community College Education particularly the E-learning and Instructional Division (BIPD) for funding our e-book project.

We hereby declare that this module is our original work. To the best of our knowledge, it contains no materials previously written or published by another person. However, if there is any, due acknowledgement and credit are mentioned accordingly in the e-book.



This e-book is specially written for Polytechnic students who are pursuing Diploma in Manufacturing Engineering. This content is designed in line with the latest syllabus prescribed in Malaysian Polytechnic and covers the topic of Manufacturing system.

Each chapters begin with learning outcomes, brief explanation on related matters and quick check questions to improve understanding.

This e-book includes diagrams and illustration and also video.

It's organized into three main chapter. Chapter one briefly explain about introduction of manufacturing. Chapter two gives the process layout and chapter three describe lean system.

---

# **PREFACE**

# TABLE OF CONTENTS

Acknowledgements	i
Preface	ii
Chapter 1	1
- Introduction of Manufacturing	
- End Of Chapter 1	8
Chapter 2	9
- Process Layout	
- End Of Chapter 2	24
Chapter 3	25
- Lean System	
- End Of Chapter 3	54
Bibliography	56

# CONTENTS

## **PUBLISHED BY:**

Politeknik Port Dickson  
KM14, Jalan Pantai, 71050 Si Rusa  
Port Dickson, Negeri Sembilan

**SEPTEMBER 2023**

**Copyright** Each part of this publication may not be reproduced or distributed in any forms by any means or retrieval system without prior written permission



# CHAPTER 1

## INTRODUCTION OF MANUFACTURING

By the end of this lesson, you should be able to :



**1.1 Elaborate on the definition and concept of the manufacturing system**

**a. Manufacturing System**

**b. Importance of manufacturing**

**c. Types of manufacturing system below :**

**i. Assembly line**

**ii. Batch production**

**iii. Computerized Integrated System**



**1.2 Apply management in manufacturing**



**1.3 Explain the principle of organization and planning**

## 1.1 a) Definition and concept of manufacturing system

- ❑ Manufacturing means the **process of converting raw material into a physical product**
- ❑ System is any **collection of parts/elements that operate interdependently to achieve common purpose**
- ❑ Manufacturing System is referred to **any collection of elements into product**



In the other side – A manufacturing system can be defined as the arrangement and operation of machine, tools, material, people and information to produce a value added physical, informational or service product whose success and cost is characterized by measurable parameters

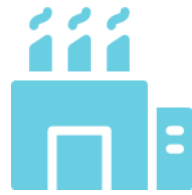


## 1.1 b) Importance of Manufacturing

- Manufactured **goods are necessary for trade**
- **National power** depends to a great extent on manufacturing power
- Manufacturing **provides the foundation for many kinds of innovations**
- The manufacturing sector is regarded as the **backbone of both social and economic development**
- **Increase the quality** and specification of the product
- **Providing superior levels of service** in providing the product
- **Enhancing the image of the product** through marketing



## 1.1 c) Types of manufacturing system

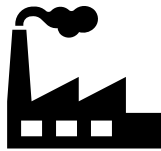


### Assembly Line



#### Definition

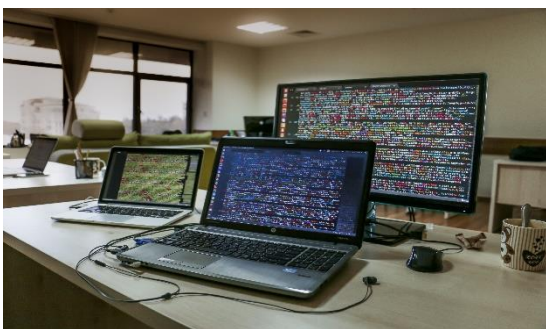
- ✓ A volume production process where products and components are moved continuously along a conveyor.
- ✓ As the product goes from one workstation to another, components are added until the final product is assembled.



### Batch production

#### Definition

- ✓ Manufacturing method where the products are made as specified groups or amounts, within a time frame.
- ✓ A batch can go through a series of steps in a large manufacturing process to make the final desired product.



### Computerized Integrated System

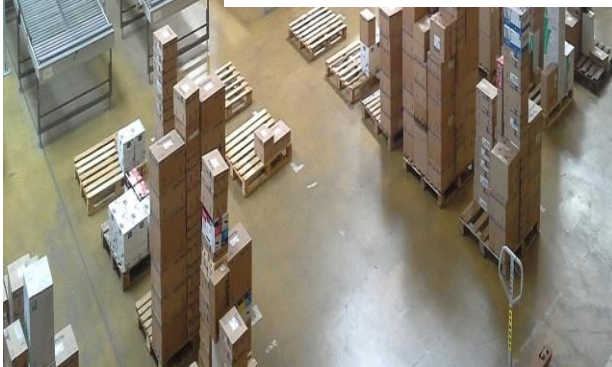
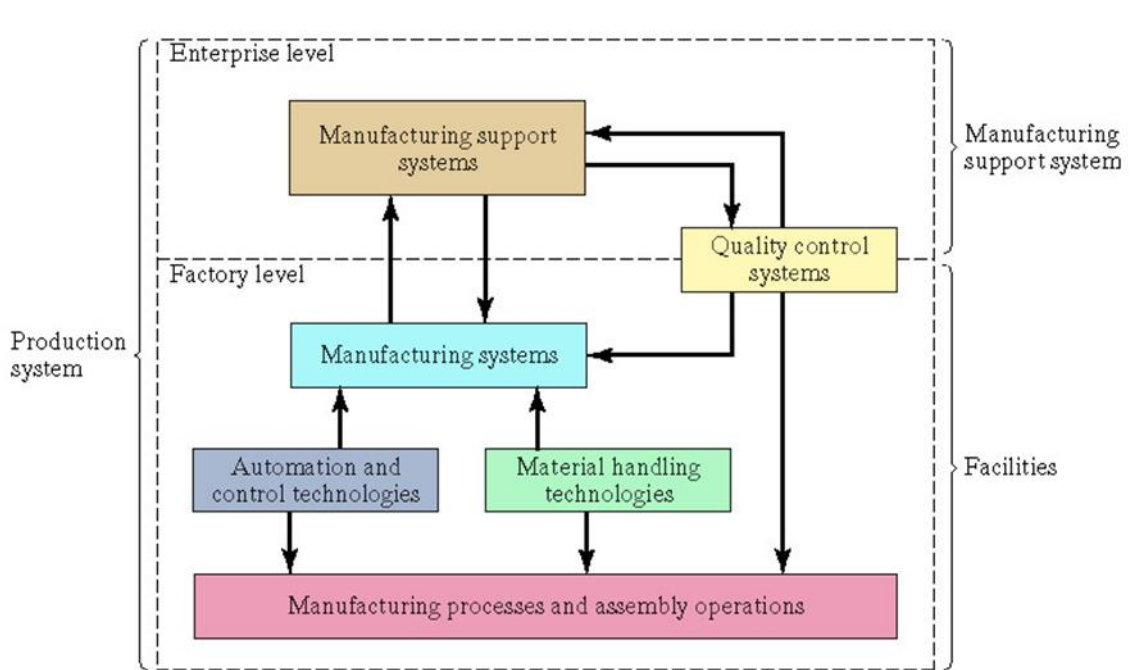
#### Definition

- ✓ Manufacturing approach of using computers to control entire production process.
- ✓ This integration allows individual processes to exchange information with each part.

## 1.2 Apply management in manufacturing



- ❑ A manufacturing system is the central element in total production system.
- ❑ Choosing a proper manufacturing system will determine the suitable element of the whole production system.



The position of the manufacturing system in the larger production system

## 1.3 Principle of organization and planning



The principle of organization and planning refers to the systematic process of arranging and structuring tasks, resources, and activities in a logical and efficient manner to achieve desired goals or objectives. It involves thinking ahead, setting objectives, determining the necessary steps, allocating resources, and establishing timelines to guide the implementation of tasks.



### 1. Goal orientation

- The process begins with a clear understanding of the desired outcome or objectives.
- Establishing specific, measurable, achievable, relevant, and time-bound goals provides a clear direction and purpose for the planning process.



### 2. Prioritization

- Effective organization and planning involve identifying and prioritizing tasks based on their importance and urgency.
- By determining which tasks are most critical or time-sensitive, resources can be allocated appropriately.



### 3. Division labor

- Breaking down complex tasks into smaller, manageable components and assigning them to individuals or teams with the necessary skills and expertise can enhance efficiency and effectiveness.
- This promotes specialization, fosters collaboration, and reduces the burden on any one person.

## 1.3 Principle of organization and planning

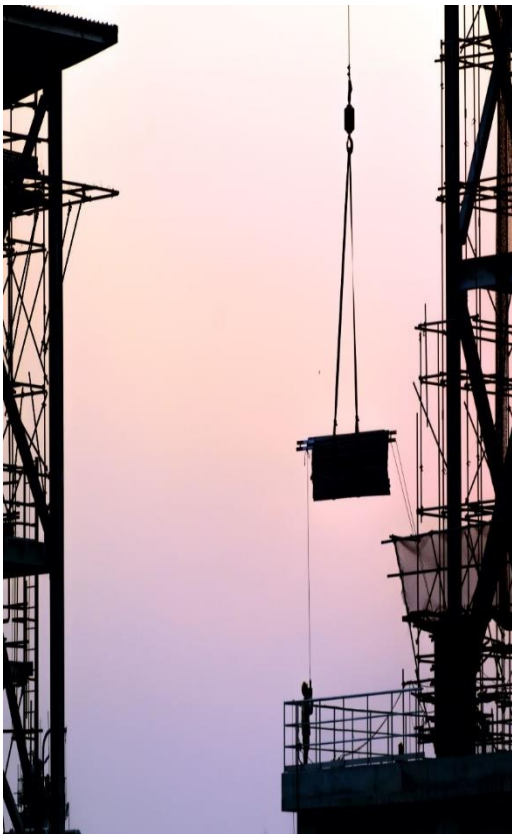
### 4. Resource allocation

- Adequate allocation of resources, including financial, human, and material resources, is crucial for successful planning and execution.
- Assessing the availability and requirements of resources and distributing them appropriately ensures smooth progress towards achieving the desired goals



### 5. Sequencing & scheduling

- Planning involves determining the order and timing of tasks to ensure a logical flow of activities.
  - Identifying dependencies between tasks and establishing realistic timelines help prevent bottlenecks and delays, enabling smooth progress towards the end goal.



### 6. Flexibility & adaptability

- While planning provides a structured framework, it is essential to remain flexible and adaptable to changing circumstances. Anticipating potential obstacles and having contingency plans in place allows for adjustments and problem-solving when unexpected situations arise.

### 7. Communication & coordination

- Effective organization and planning rely on clear communication channels and coordination among individuals or teams involved.
- Regular updates, feedback, and collaboration facilitate a shared understanding of goals and progress, ensuring everyone is aligned and working towards the same objectives.

### 8. Monitoring & evaluation

- Regular monitoring and evaluation of progress against the set goals help identify deviations, areas for improvement, and opportunities for optimization.
- Adjustments can be made to the plan as needed to maintain focus and ensure the desired outcomes are achieved.



# END OF CHAPTER 1 EXERCISE

## QUESTION 1

- a) Different types of manufacturing systems are used in industry, such as assembly lines, batch production lines, and computer integrated systems. Briefly explain batch production and **TWO (2)** of its advantages.

## SUGGESTED ANSWER



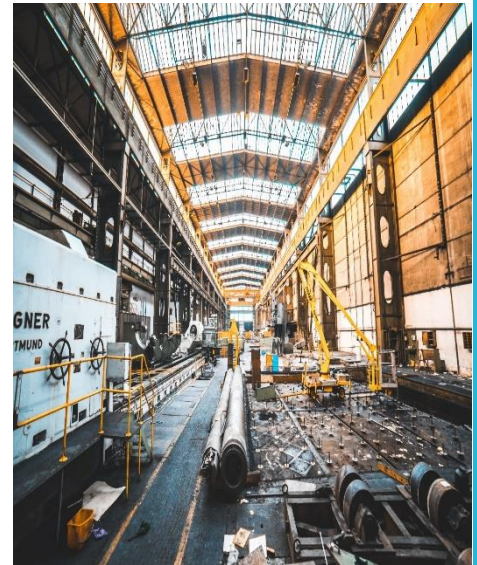
# CHAPTER 2

# PROCESS LAYOUT

**By the end of this lesson, you should be able to :**

## **2.1 Organize the process layout in manufacturing**

- a. Layout planning
- b. 4 basic layout types :
  - i. Flexible flow layout
  - ii. Line flow layout
  - iii. Hybrid layout
  - iv. Fixed position layout



## **2.2 Expose the concept of Flexible Manufacturing System (FMS)**

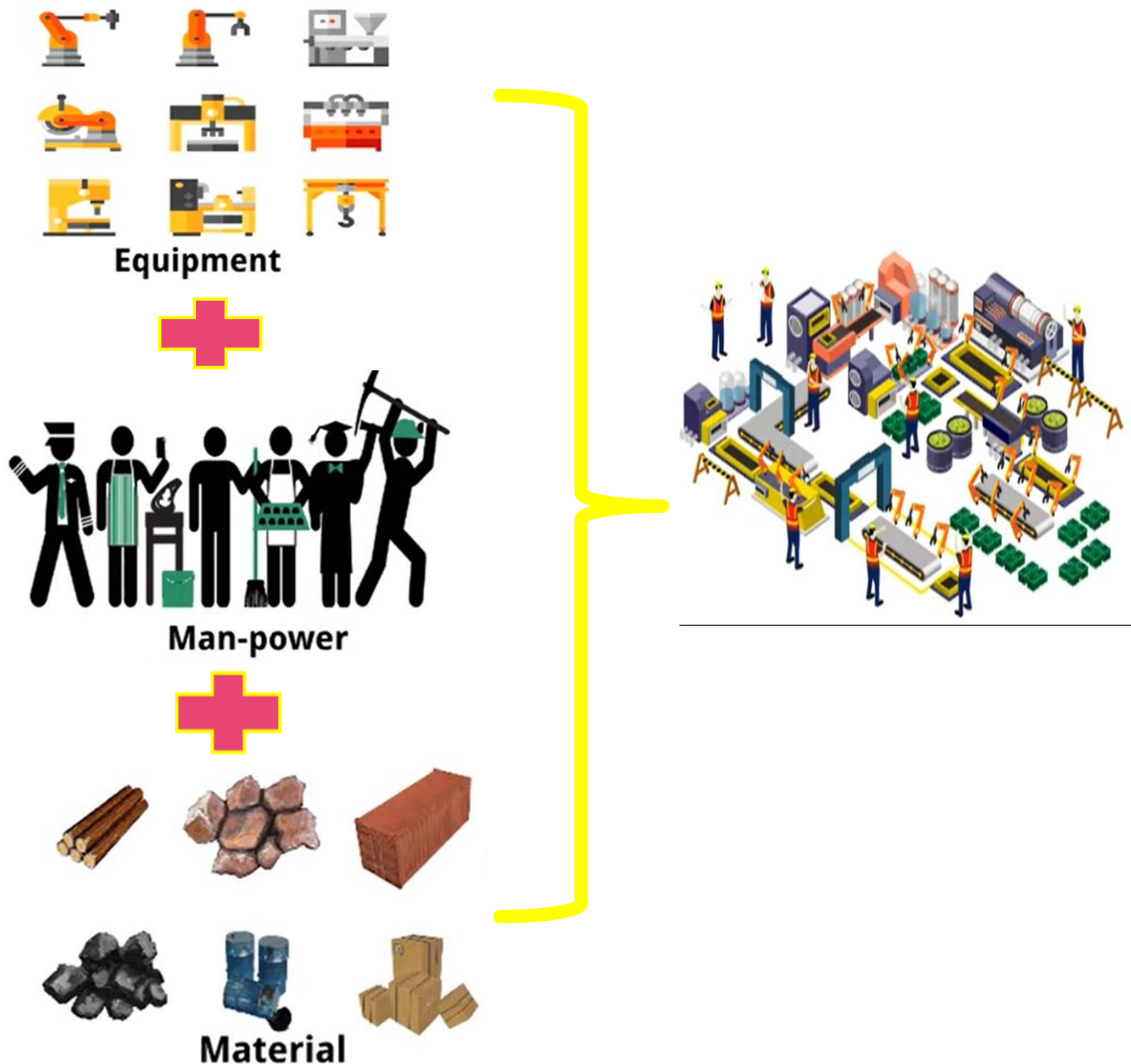
- a. Demonstrate of Flexible Manufacturing System
- b. The FMS components :
  - i. Hardware components
  - ii. FMS software and control functions
  - iii. Human labor
- c. The application of FMS
  - i. Role of FMS
  - ii. Concept of FMS
  - iii. Component of FMS
  - iv. Application and benefit of FMS
- d. The role of Computer Integrated Manufacturing ( CIM )
  - i. Concept of CIM
  - ii. Implementation of CIM
  - iii. Benefit of CIM

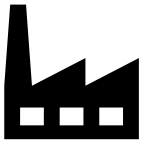


# What is Process Layout

- In manufacturing engineering, process layout is a design for the floor plan of a plant which aims to improve efficiency by arranging equipment, material, man-power and other facilities / services according to its function.

The production line should ideally be designed to eliminate waste in material flows, inventory handling and management.





## Objectives of Process Layout

To **eliminate bottlenecks** and **point of congestion** by mean of line balancing, thus minimize the usage of material transportation and material handling.

To **minimize the movement** of the workers within the workstation

- **Waiting time** for the semi-finished product is minimized.

- **Increase the flexibility of changes** in product design and future modification.

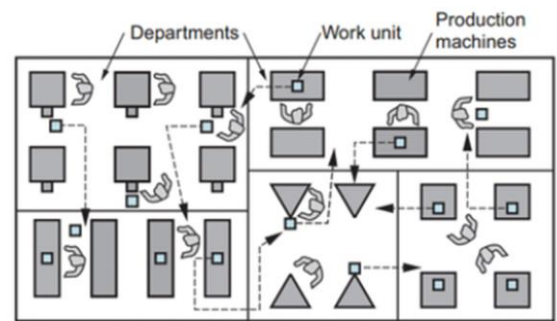
- **Increase the utilisation of cubic space** which govern floor space and ceiling space.

- To make the workspace **safe**, ventilated and free from dust, fume, etc which lead to satisfaction of the worker.

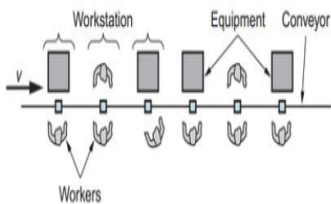
# Types Of Process Layout

## 1. Flexible Flow Layout

- A layout that organizes resource (employee and equipment) by function rather than by service or product. Also known as Process Layout
- It is useful when the production process is organized in batches
- Personnel and equipment to perform the same function are allocated in the same area



## 2. Line Flow Layout



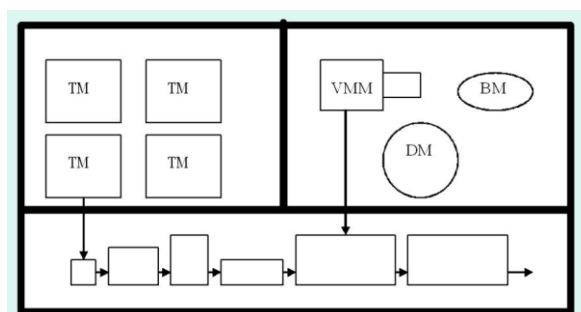
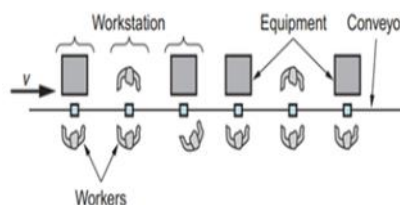
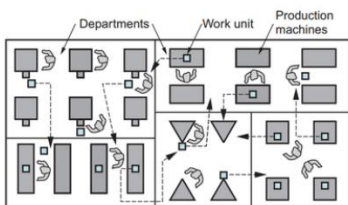
- A layout in which workstation or department are arranged in a linear path. Also known as Product Layout (Assembly line)

Machinery and Materials are placed following the product path

- Machine are placed as close as possible to the next one in line, in the correct sequence to manufacture the product

## 3. Hybrid Layout

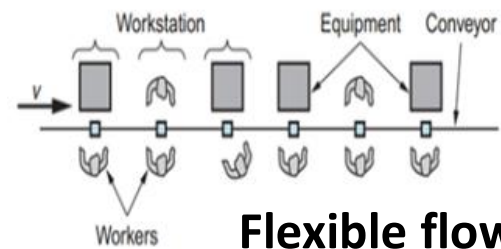
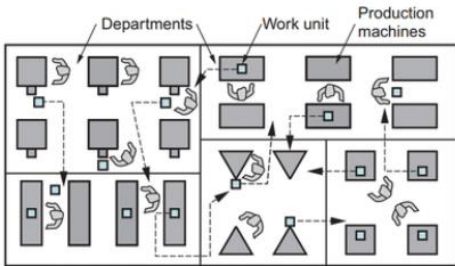
- An arrangement in which some portion of the facility have flexible flow layout and others have line flow layout



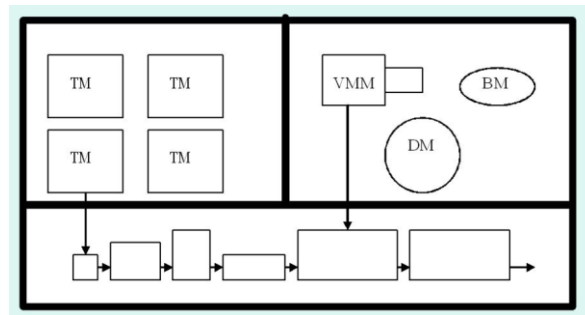
# Types Of Process Layout

## 4. Hybrid Layout

- An arrangement in which some portion of the facility have flexible flow layout and others have line flow layout

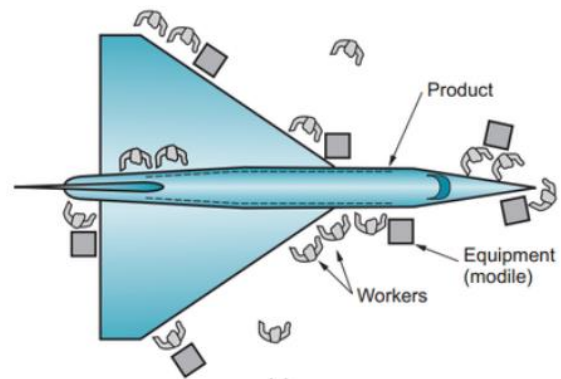


**Flexible flow layout +  
Line flow layout  
=  
Hybrid layout**



## 5. Fixed Position Layout

- An arrangement in which the service and manufacturing site is fixed in place and employees and equipment come to the site to perform their tasks.



# Factors Affecting Layout Decision

## 1. Material

- ✓ The layout of the productive equipment will depend on the characteristic of the product to be managed in the facility, as well as the different parts and materials to work on
- ✓ Main factor to be considered : size, shape, volume, weight and the physical-chemical characteristic

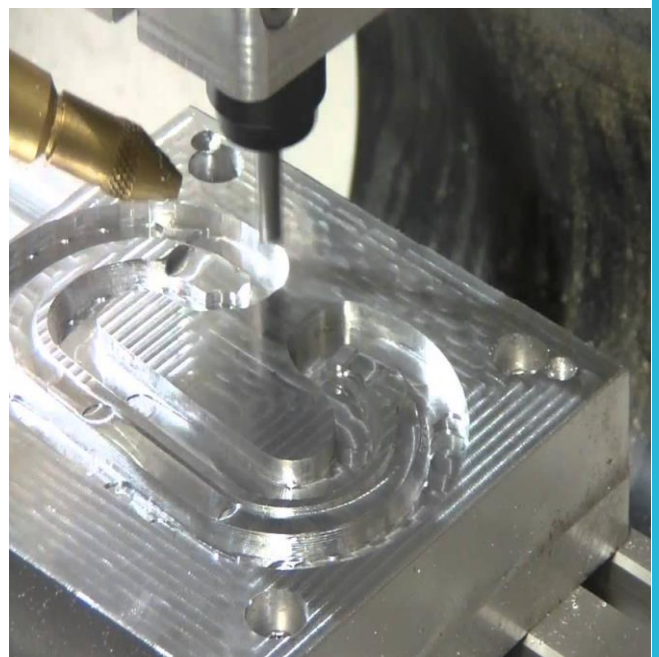
**Example :**

### *Hazardous material*

Need to use layout with a good material handling and minimum human involvement, thus Line Flow layout is the most suitable to be used.

### *Light metal*

Aluminum is a light metal which can be transferred easily between each machine. Thus, using Flexible Flow layout should do the job without need to invest in complicated material handling system.



## 2. Machinery

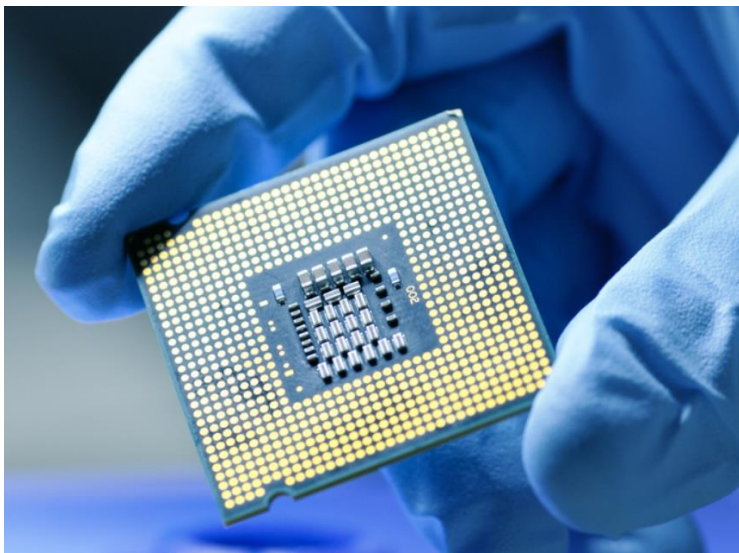
- Having information about processes, machinery, tools and necessary equipment as well as their use and requirements is essential to design a correct layout
- Several machines properties need to be consider which is type of machine, quantity, size and required worker as it will determine the type of layout design.



**Example :**

### ***Semiconductor component***

Semiconductor component assembly process required several dedicated machine for each process. To ease with production planning, machine arrangement, and to manage high production rate demand, Flexible Flow Layout is the most suitable layout.



### 3. Labor

- Labour has to organized in the production process based on these 2 factors :
  - Environment consideration : employees' safety, light condition, ventilation, etc
  - Process consideration : personnel qualification, flexibility, number of worker, etc.



#### Example :

#### Automotive

All dedicated labor should be group together to ease the job while the vehicle is being handled with a dedicated material handling system. Hybrid layout is the best option to perform this task



## 4. Auxiliary Services

- Support the main production activities at the plant :
  - Related to labour : accessibility paths, fire protection installation, supervision, safety, etc
  - Related to material ; quality control
  - Related to machinery : maintenance and electrical and water lines

### Example :

Oil refinery

In order to install safety equipment, electrical / water / oil line, it required large space. Thus Line Flow Layout is the best option



## 5. Future Changes

- One of the main objectives of plant layout is flexibility
- It is important to forecast the future changes to avoid having an inefficient plant layout in a short term
- Possible future extensions of the facility must be taken into consideration as well as the feasibility of product during re-layout

### Example :

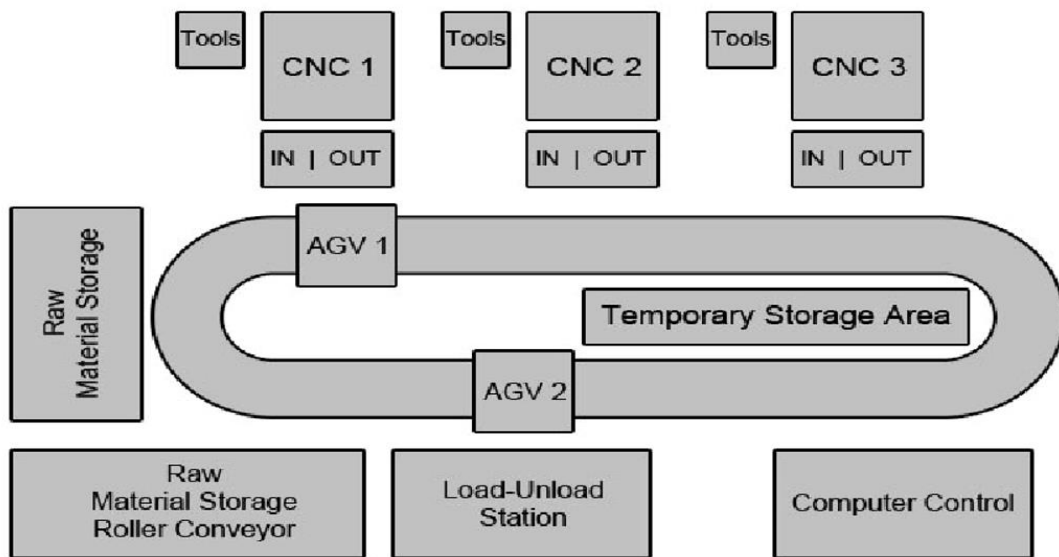
Furniture workshop

Demand on furniture are dynamic, thus a furniture workshop need to cope with a layout demand frequently. Flexible Flow Layout is to be use as changes can be made in the target workstation without interrupting others



## Concept of Flexible Manufacturing System (FMS)

- A Flexible Manufacturing System (FMS) is an automated machine cell, consisting of a group of processing workstation, interconnected with automated material handling and storage system.
- External changes such as change in product design and production system can be done easily
- Optimizing the manufacturing cycle time
- Reduce production cost
- Overcoming internal changes like breakdowns, etc



Layout machining using FMS

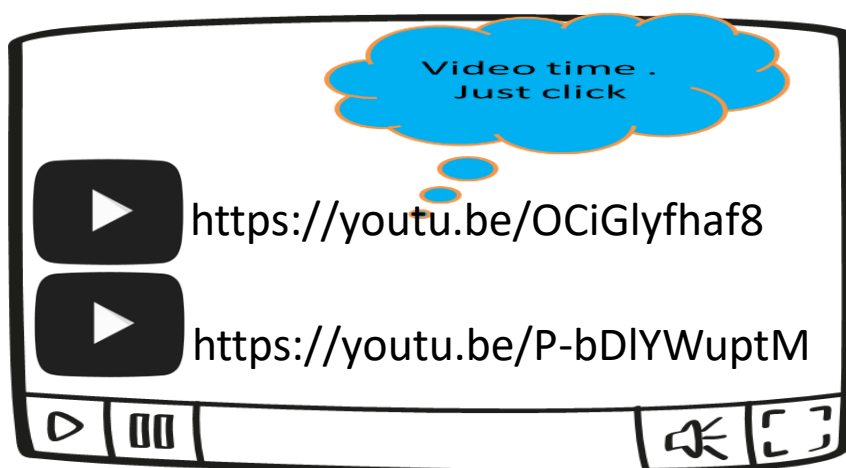


# FMS Component

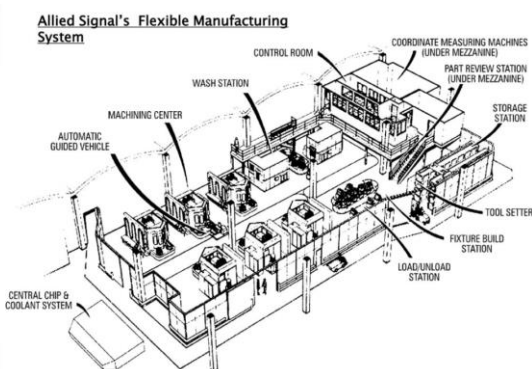
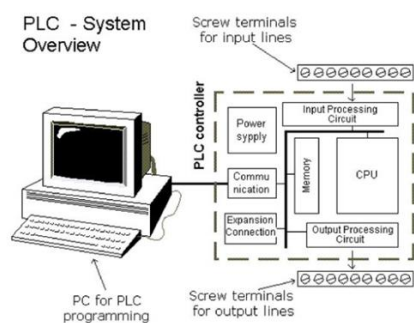
## 1. Workstation

- Basically, workstation is the place where all the manufacturing process take place which consist of :
  - Load / Unload station
  - Machining station
  - Other processing station (finishing, inspection, etc)
  - Assembly

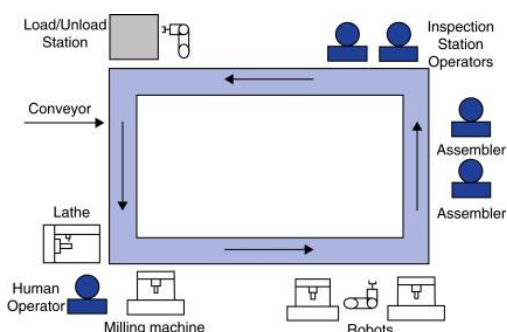
## 2. Automated Material Handling and Storage System



## 3. Computer Control System

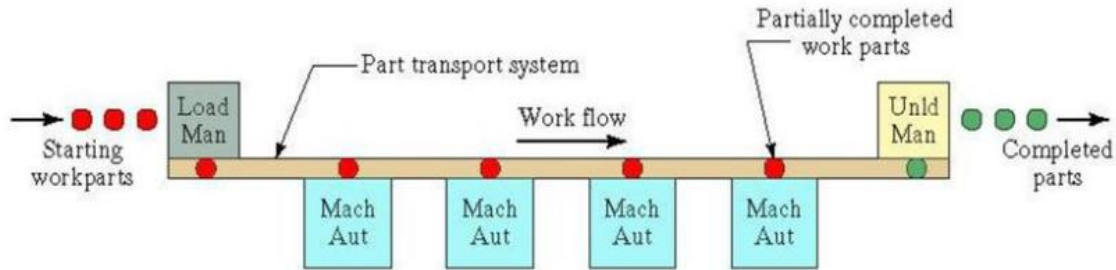


## 4. Labor

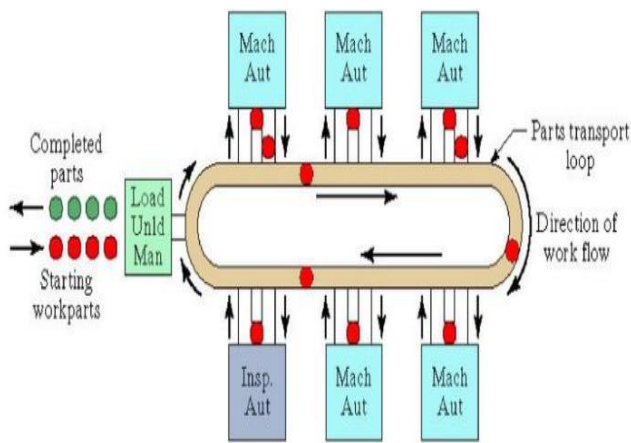


# Layout of Flexible Manufacturing System

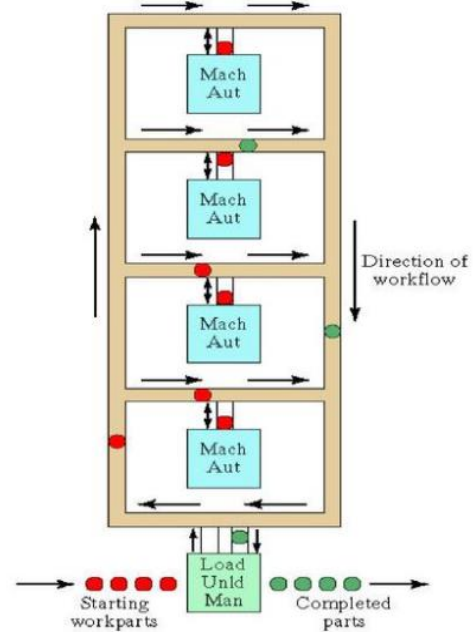
## 1. Progressive or Line Type



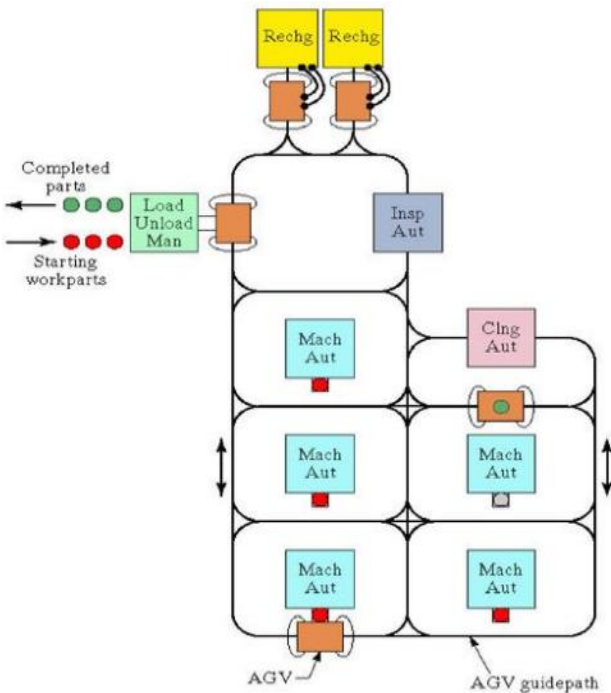
## 2. Loop Type



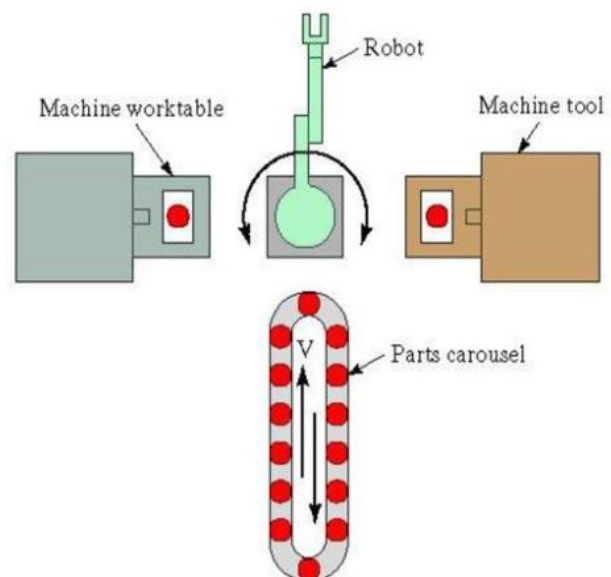
## 3. Ladder Type



## 4. Open field Type

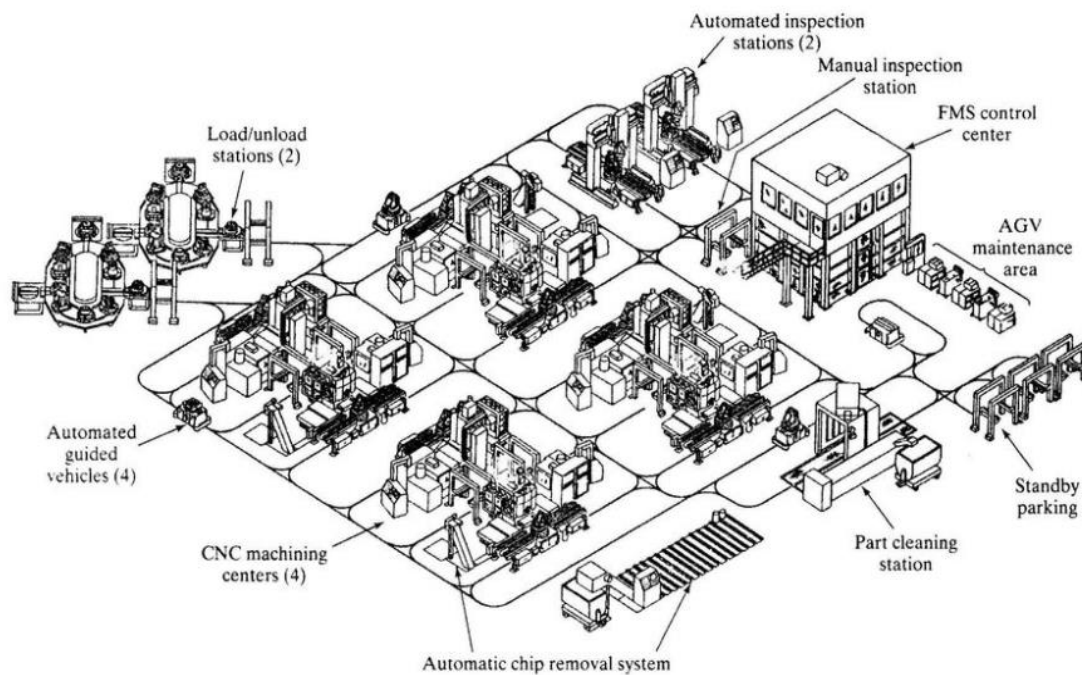


## 5. Robot Centered Type



# Application of Flexible Manufacturing System

Flexible Manufacturing Systems (FMS) are versatile production systems that use **computer-controlled machines** and **automated material handling** to produce a wide range of products efficiently and cost-effectively.



## Advantages

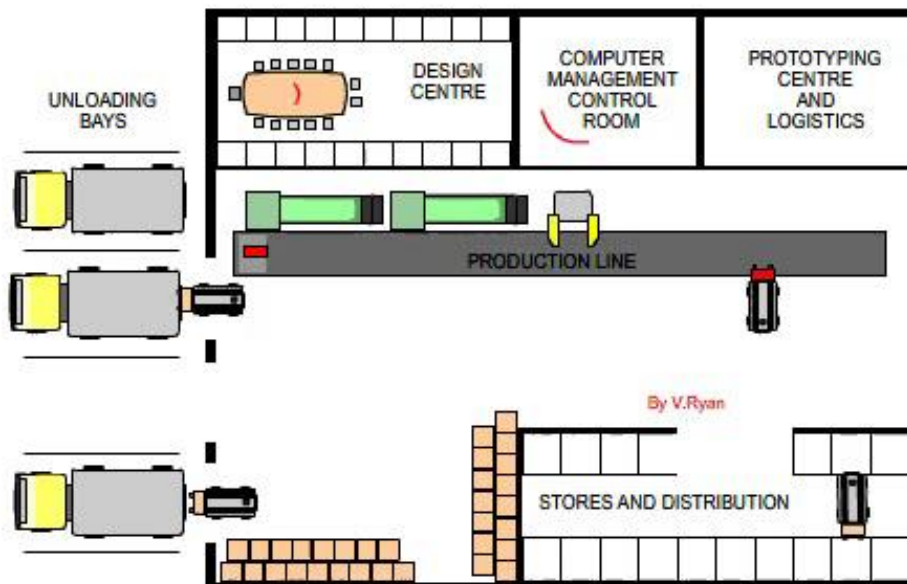
1. Reduce set up and queue times
2. Improve efficiency
3. Reduce manufacturing lead time
4. Improve human force utilization
5. Produce variety of product under one roof
6. Increase product quality
7. Serve a variety of vendors simultaneously

## Disadvantages

1. Substantial pre-planning activity
2. Expensive

# Computer Integrated Manufacturing (CIM)

- ✓ Computer Integrated Manufacturing (CIM) describe as the computerized integration of product design, planning, production , distribution and management.
- ✓ CIM depends on usage of a large-scale integrated communication system.
- ✓ Requires extensive database containing technical and business information.
- ✓ CIM system consist of subsystem that are integrated as a whole, such as
  - ✓ Business planning and support
  - ✓ Product design
  - ✓ Manufacturing process planning
  - ✓ Process automation and control
  - ✓ Factory-floor monitoring system



CIM



# Computer Integrated Manufacturing (CIM)

## Benefit of CIM

- 1 Shorter product life cycle
- 2 Product quality and uniformity
- 3 Better use of resources
- 4 Better control of the processes





# END OF CHAPTER 2 EXERCISE

## QUESTION 1

- a) A flexible Manufacturing System (FMS) is an automated machine cell, consisting of a group of processing workstation, interconnected with automated material handling and storage system.
- i) Identify **THREE (3)** components of Flexible Manufacturing System and briefly explain ONE(1) of the components.
- i) Sketch Loop Type Layout, Robot Centered Type and Ladder Type Layout of Flexible Manufacturing System

## SUGGESTED ANSWER

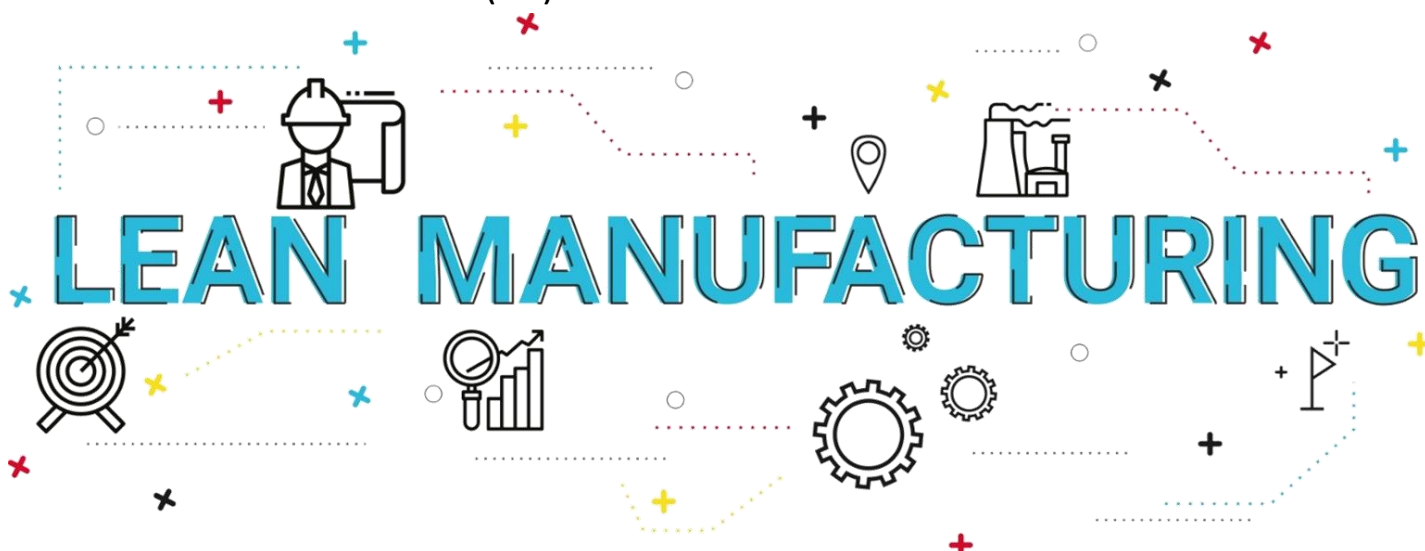


# CHAPTER 3

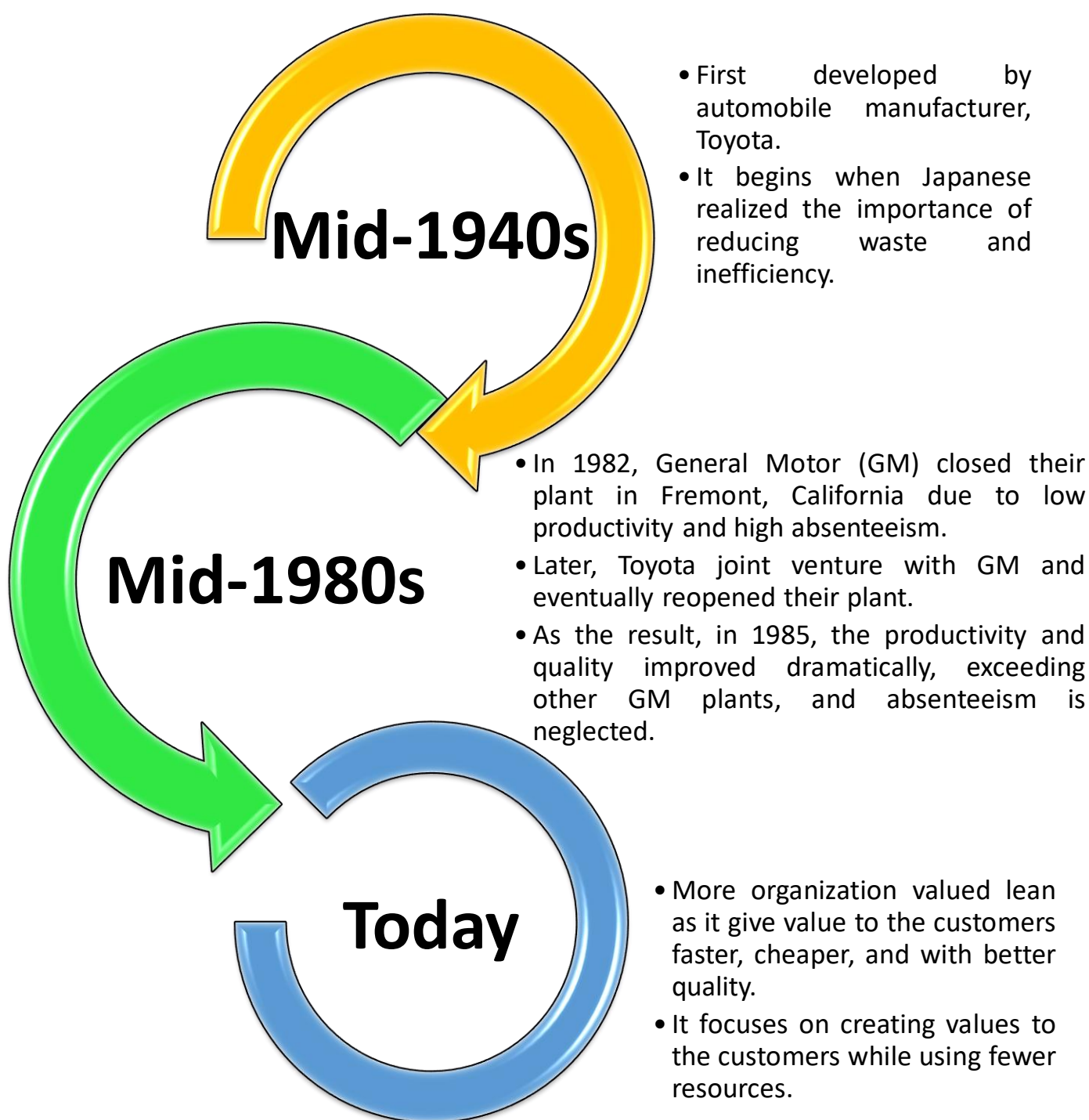
## LEAN SYSTEM

By the end of this chapter, you should be able to:

- 3.1 Determine the Lean Systems and Lean Productions in manufacturing.
- 3.2 Classify the characteristics of the Lean System for services and manufacturing
  - a. Full method of workflow
  - b. Quality at the source
  - c. Small lot sizes
  - d. Uniform workstation loads
  - e. Standardized components and work methods
  - f. Close supplier ties
  - g. Flexible workforce
  - h. Line flows
  - i. Automation
  - j. 5 S
  - k. Preventive maintenance
- 3.3 Characterize continuous improvement by using a Lean System approach.
  - a. Kaizen
  - b. Kanban System
  - c. Value Stream Mapping (VSM)
  - d. Just-in-time (JIT)



# REVOLUTION OF LEAN



# TOYOTA PRODUCTION SYSTEM (TPS)

Toyota Motor Corporation produce more than 9 million cars and trucks equivalent to \$220 billion per year. It is one of the largest vehicle manufacturer in the world. Toyota have been recognized as one of the first production company to address the important of reducing waste in achieving high efficiency. The production system is based on the philosophy of striving the complete elimination of all waste in pursuit of the most efficient methods.



## Total Production System (TPS)

- A strategy when complete elimination of waste is done to achieve the most effective methods.

Scan me



# THE TOYOTA APPROACH

The Toyota Production System (TPS) has served as a template for several lean system deployments, especially in manufacturing. The following are just a few of the Toyota-specific terminology that are frequently used in association with lean operations today:

Muda	<ul style="list-style-type: none"><li>• Waste and inefficiency</li></ul>
Kanban	<ul style="list-style-type: none"><li>• A manual mechanism for managing the transfer of components and materials that reacts to signal of demand for the supply of components or suppliers.</li></ul>
Heijunka	<ul style="list-style-type: none"><li>• Waste results from variations in output volume. To ensure a consistent flow of labor, the workload must be balanced; volume and variety must be averaged.</li></ul>
Kaizen	<ul style="list-style-type: none"><li>• The system is being continually improved. There's always opportunity for improvement, therefore this effort needs to go on.</li></ul>
Jidoka	<ul style="list-style-type: none"><li>• Superiority at the source. When a machine recognizes a defective component, it shuts down automatically. The line is stopped by an employee, also known as autonomy.</li></ul>

# LEAN SYSTEM

A flexible system of operation known as a "lean operation" makes use of a lot less material (such as activities, personnel, inventory, and floor space) than a conventional system. Lean systems typically outperform non-lean systems in terms of productivity, cost-effectiveness, cycle time, and quality. Because of the closely linked activities and timely delivery of goods that characterize lean systems, they are sometimes referred to as just-in-time (JIT) systems. The lean approach was pioneered by Toyota's founder, Taiichi Ohno, and Shigeo Shingo as a much faster and less costly way of producing automobiles.

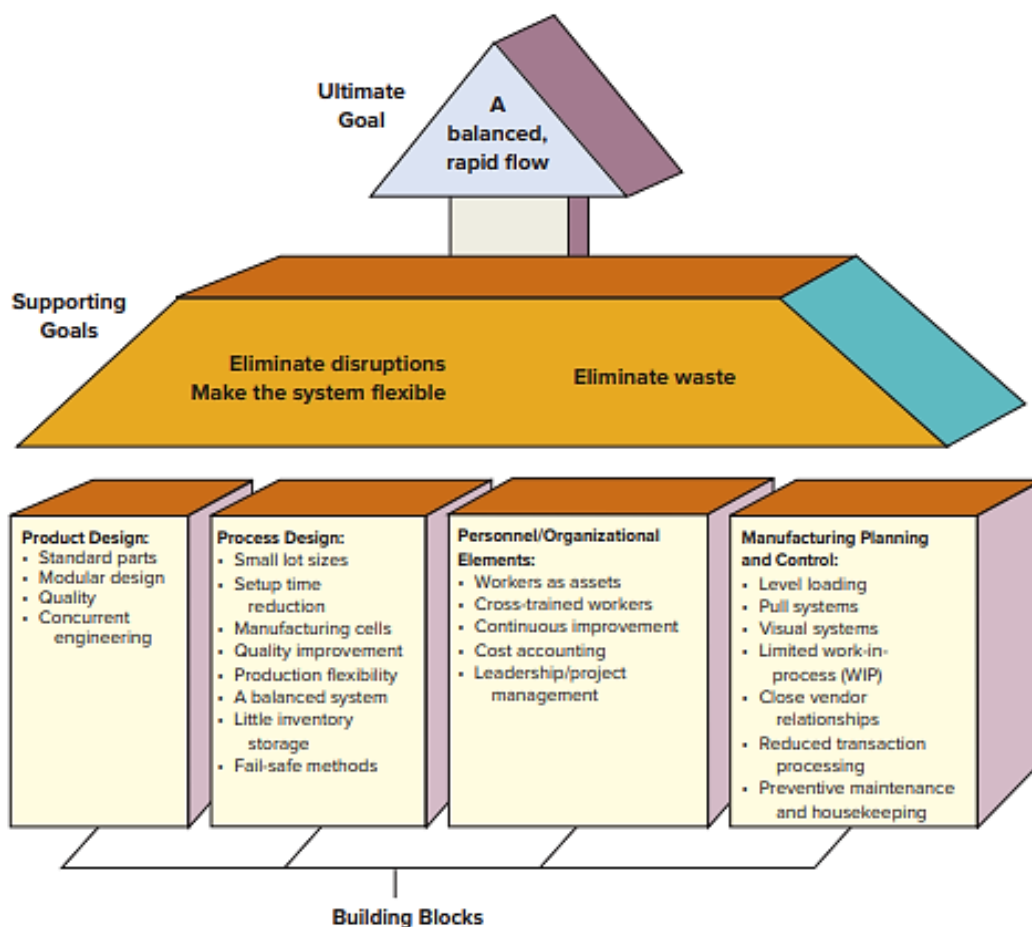
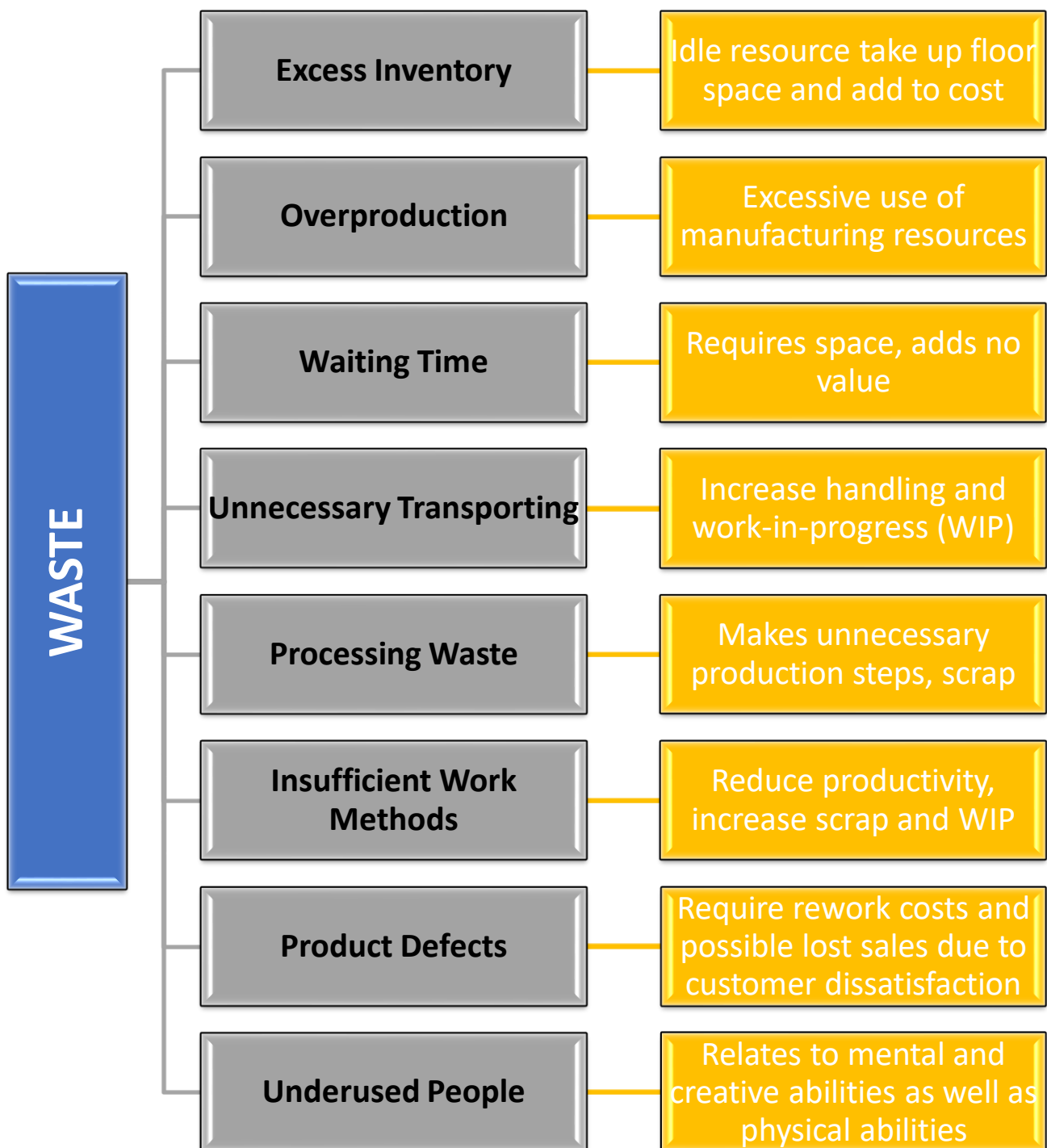


Figure 3.1 : An overview of the goals and building block of lean production system

# TYPES OF WASTE

Lean approach address waste as unproductive resources. Eliminating waste can increase output and free up resources because waste is a representation of wasted resources. In lean philosophy, it outline eight types of waste:



# JUST-IN-TIME (JIT), TOYOTA PRODUCTION SYSTEM (TPS) AND LEAN SYSTEM

## **JUST-IN-TIME (JIT)**

The belief that waste can be eliminated by cutting unnecessary capacity or inventory and removing non-value-added activities in operations.

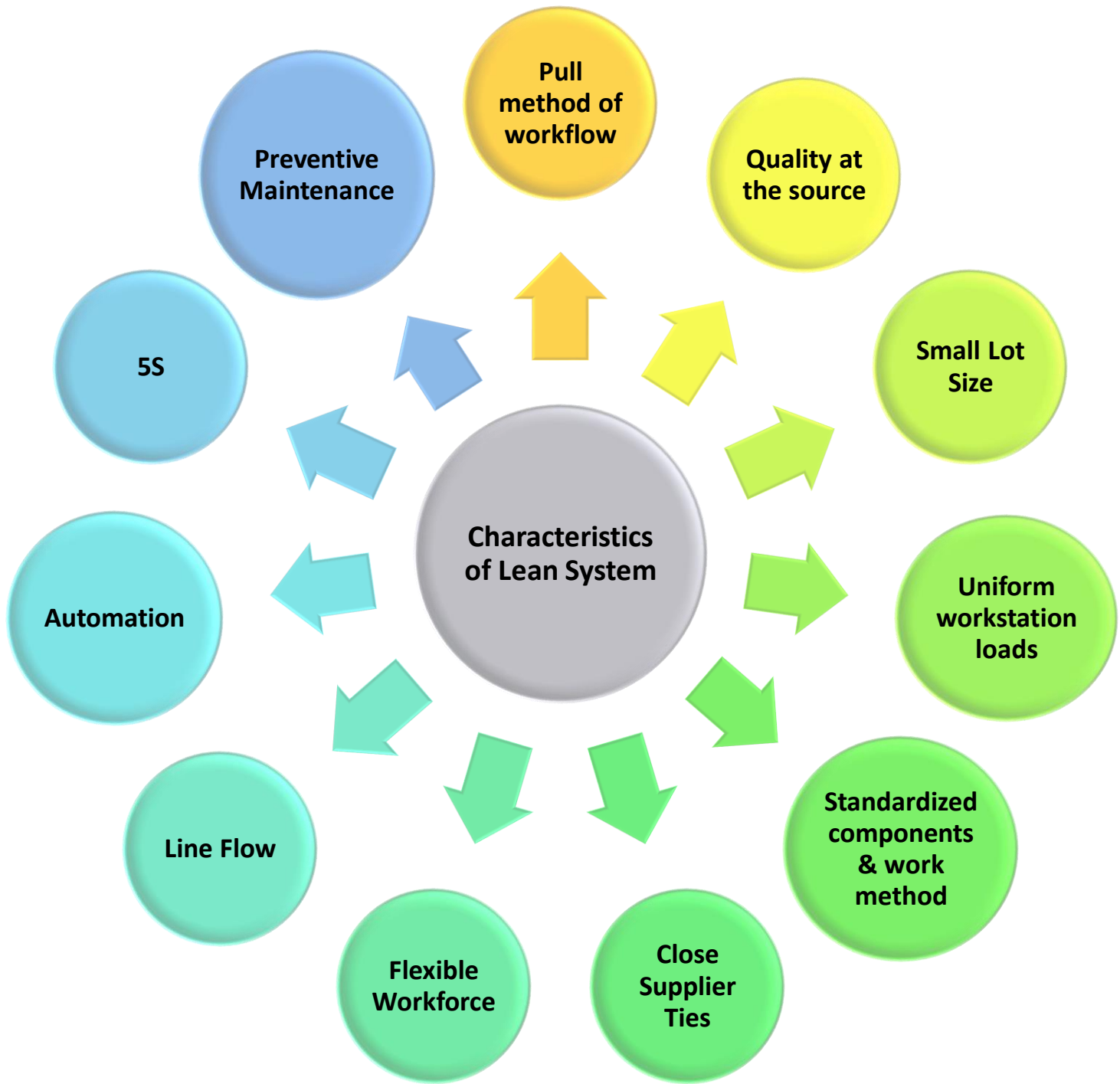
## **TOYOTA PRODUCTION SYSTEM (TPS)**

- Focus on continuous improvement, respect for people, and standard work practices.

## **LEAN SYSTEM**

- Operations systems that reduce wasteful resources and delays from each of a company's activities in order to optimize the value added.

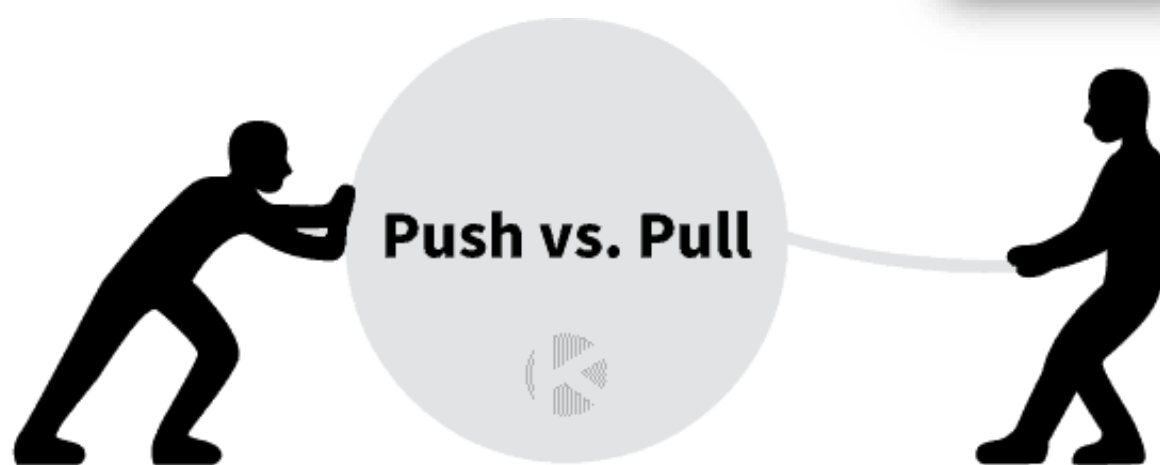
# CHARACTERISTICS OF LEAN SYSTEM



# PULL METHOD OF WORKFLOW

The phrases "push" and "pull" refer to two distinct methods for transferring work along a production process. A **push system** is employed in conventional production settings. When work is completed at one workstation, the output is pushed to the following station or, in the case of the final operation, to final inventory. On the other hand, with a **pull system**, controlling movement The subsequent action completes the task; When necessary, each workstation pulls the output from the station before it; Customer demand or the master schedule determine the output of the final operation. As a result, workloads may increase at workstations that are running behind schedule due to equipment malfunction or the discovery of a quality issue.

Scan me



**Make all we can just in case**  
**Make-to-stock**

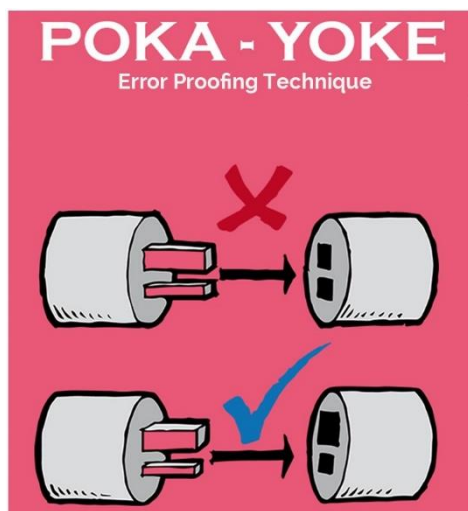
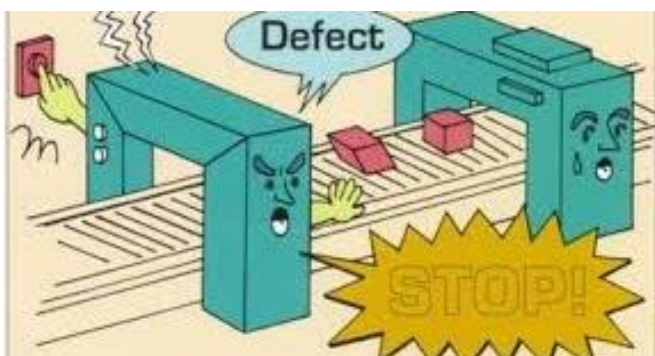
- Production is approximated
- Based on anticipation
- Inventories are high
- There is waste

**Make what's needed when needed**  
**Make-to-order**

- Production is precise
- Based on actual consumption
- Inventories are low
- Waste is reduced

# QUALITY AT THE SOURCES

- The quality defect that occurs during production may disrupt the flow of the process. Thus, quality at the source come to light as the organization-wide effort to improve the quality of a firm's products by having employees act as their own quality inspectors in order to minimal the defects during production.
- One approach for implementing quality at the source is to use **poka-yoke**, mistake-proofing methods aimed at designing fail safe systems that minimize human error.
- Another approach for implementing quality at the source is a practice the Japanese call **jidoka**, and **andon**, which gives machines and machine operators the ability to detect when an abnormal condition has occurred.
- It consist of two working mechanism where the first one will detect defects when it occur while the other is where the worker stopped the production to correct the cause of the defects.



## POKA - YOKE



It's a Methodology  
to  
Design Proces  
So that it  
doesn't allow  
errors to occur

www.endromeda.com  
info@endromeda.com  
+971-24093221



Scan me



# SMALL LOT SIZES

In lean philosophy, it is practical to have minimum lot sizes (e.g., multiple items operate simultaneously in one machine). The goal of lean is to reduce lot size as much as possible.

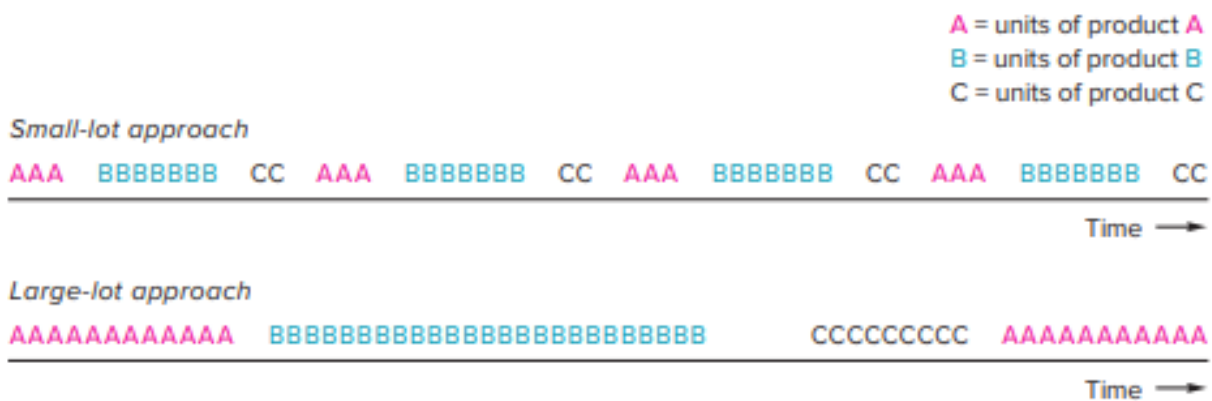
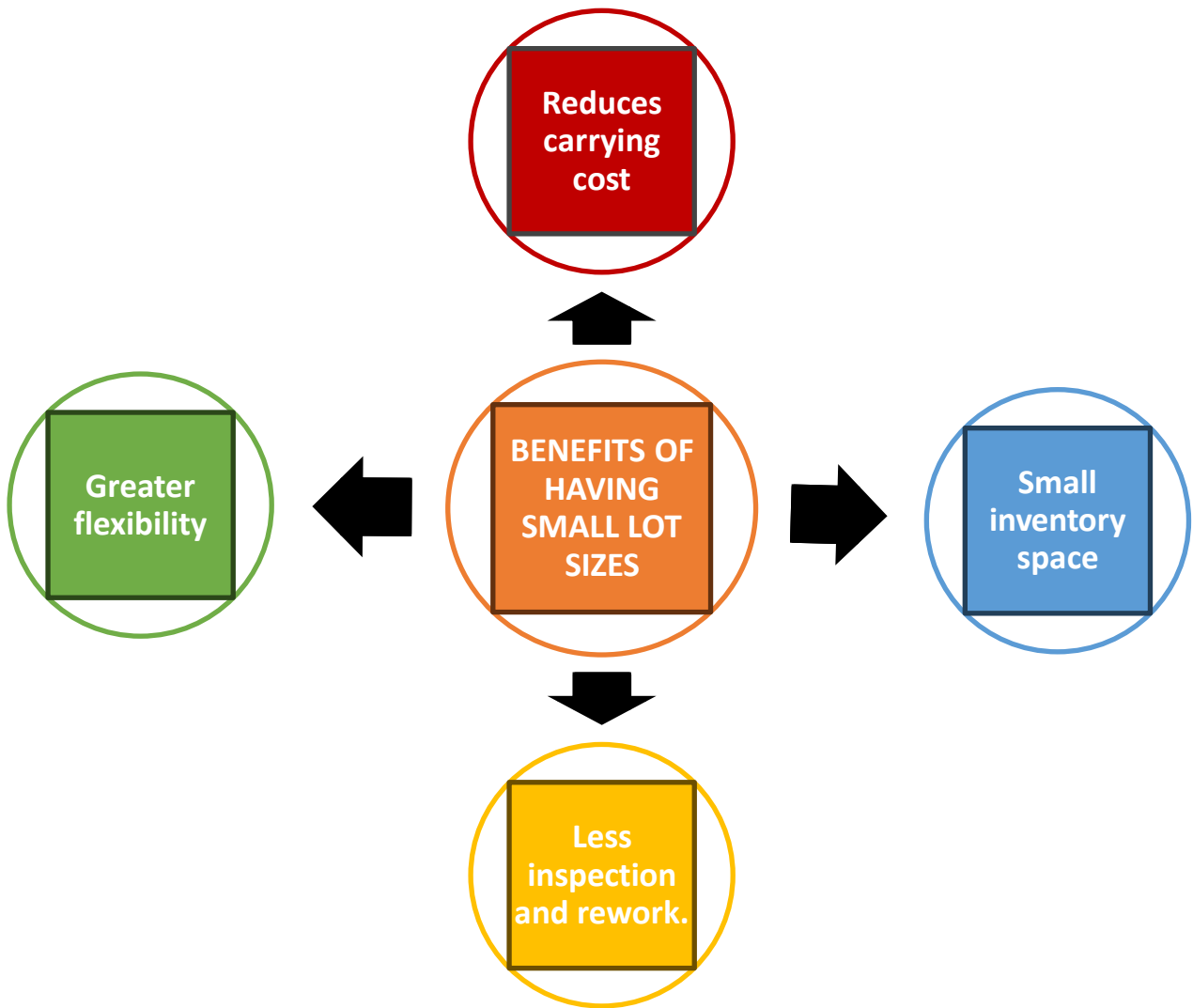


Figure 3.4 : Small versus large-lot run sizes

## UNIFORM WORKSTATION LOADS

- A lean system works best if the daily load on individual workstations is relatively uniform.
- Service processes can achieve uniform workstation loads by using reservation systems (e.g., scheduled surgeries) and differential pricing to manage the demand.
- For manufacturing processes, uniform loads can be achieved by assembling the same type and number of units each day, thus creating a uniform daily demand at all workstations.
- **Mixed-model assembly** produces a mix of models in smaller lots.



# STANDARDIZED COMPONENTS AND WORK METHODS

A standardized work method, on the other hand, refers to a consistent and defined approach to completing tasks or projects. It involves establishing a set of procedures, guidelines, and best practices to streamline processes and achieve consistent results. Standardized work methods offer various advantages, including:



**1.Consistency:** Just like standardized components, standardized work methods ensure that tasks are performed the same way every time, reducing errors and variations in outcomes.

**2.Efficiency:** With clear and standardized procedures, tasks can be completed more quickly and with fewer disruptions, leading to higher productivity.

**3.Training and Onboarding:** New team members can be onboarded more effectively since they can follow established procedures. This reduces the learning curve.

**4.Continuous Improvement:** Standardized work methods provide a baseline for measuring performance and identifying areas for improvement.

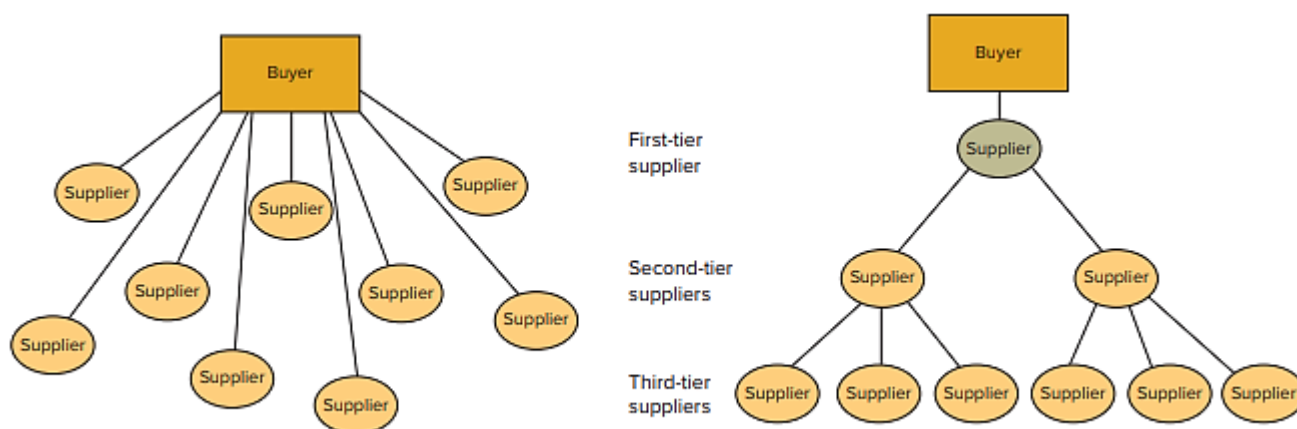
**5.Quality Improvement:** By having standardized steps that are known to produce quality results, the overall quality of work is likely to improve.

**6.Documentation:** Standardized work methods often come with documentation that makes it easier to track progress, identify issues, and make adjustments as needed.

**7.Risk Reduction:** Standardized methods often incorporate best practices and lessons learned, reducing the likelihood of mistakes or failures.

## CLOSE SUPPLIER TIES

- Traditionally, production works on hundreds or even thousands of suppliers in a highly centralized arrangement where the representative of the company speaks directly with the suppliers. In traditional approach, each suppliers does not communicate with each other. They work based on specification give by the company.
- While, in lean systems, it typically have a close supplier's relationship which is expected to deliver small frequent product of high-grade goods. It may employ a tiered approach with suppliers where they relatively work directly with the company or with those who supply major subassemblies.



Traditional supplier versus suppliers tiers. Retrieved from Jeffery Miller Vollmann "The Hidden Factory," *Harvard Business Review*, September/October 1985, pp. 141- 50. Copyright © 1985 by the Harvard Scholl Publishing Corporation.

## LINE FLOW & AUTOMATION

- **Line Flows:** Managers of hybrid-office and back-office service processes can organize their employees and equipment to provide uniform workflows through the process and, thereby, eliminate wasted employee time.
- Another tactic used to reduce or eliminate setups is **the one-worker, multiple-machines (OWMM)** approach, which essentially is a one-person line.
- **Automation** plays a big role in lean systems and is a key to low-cost operations.

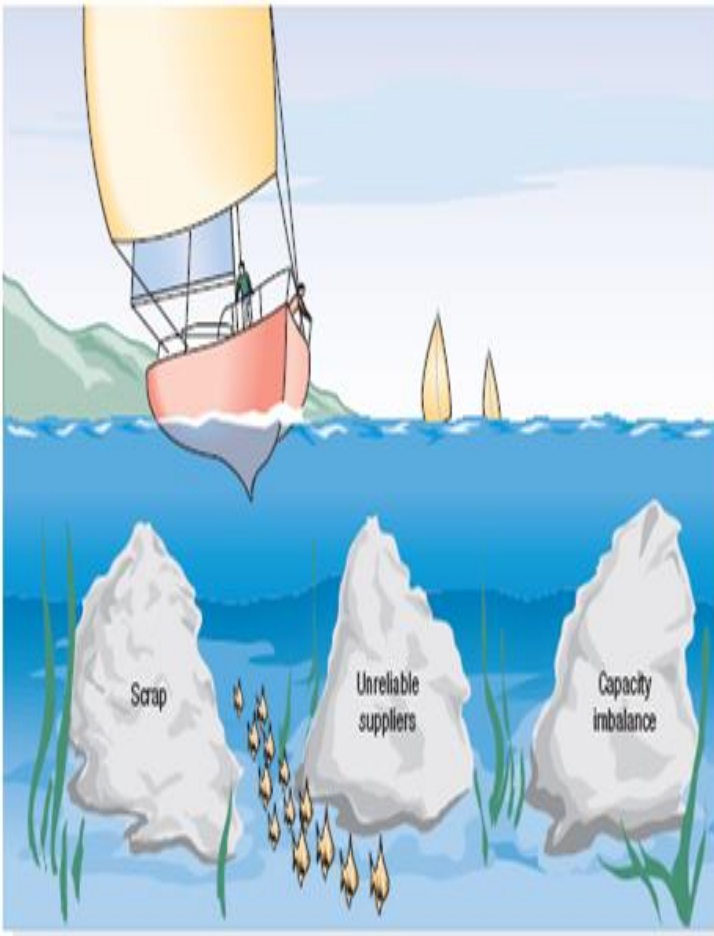
## FLEXIBLE WORKFORCE

The overall goal of a lean system is to achieve the ability to process a mix of products or services in a smooth flow. One potential obstacle to this goal is bottlenecks that occur when portions of the system become overloaded. The existence of bottlenecks reflects inflexibilities in a system. Process design can increase product flexibility and reduce bottlenecks in variety of ways.



# LINE BALANCING

**Line balancing** of production lines (i.e., distributing the workload evenly among workstations) helps to achieve a rapid flow of work through the system. Time needed for work assigned to each workstation must be less than or equal to the cycle time. The cycle time is set equal to what is referred to as the takt time. (Takt is the German word for musical meter.)



**Takt time** is the cycle time needed in a production system to match the pace of production to the demand rate. It is sometimes said to be the heartbeat of a lean production system. Takt time is often set for a work shift. The procedure for obtaining the takt time is:

1. Determine the net time available per shift by subtracting any nonproductive time from total shift time.
2. If there is more than one shift per day, multiply the net time per shift by the number of shifts to obtain the net available time per day.
3. Compute takt time by dividing the net available time by demand.

## COMPUTING *TAKT* TIME

Computing takt time using the given information. Total *takt* time per shift is 480 minutes per day, and there are two shifts per day. There are two 20-minute breaks and a 30-minute lunch break per shift. Daily demand is 80 units.

### Compute net time available per shift:

Total time	480 minutes
Rest breaks	- 40 minutes
Lunch breaks	<u>- 30 minutes</u>
	410 minutes

### Compute the net time available per day:

	410 minutes per shift
X	<u>2 shifts/day</u>
	820 minutes/day

### Compute *takt* time:

$$\begin{aligned}
 \text{Takt time} &= \frac{\text{Net time available per day}}{\text{Daily Demand}} \\
 &= \frac{820 \text{ minutes per day}}{80 \text{ units per day}} \\
 &= 10.25 \text{ minutes per cycle}
 \end{aligned}$$

# 5S

5S is a methodology consisting of five workplace practices conducive to visual controls and lean production.



## Sort (Seiri)

- Decide which items are needed to accomplish the work and keep only those items.

## Set in Order (Seiton)

- Organize the workplace so that the needed items can be accessed quickly and easily.

## Shine (Seiso)

- Keep the workplace clean and ready for work. Perform equipment maintenance regularly.

## Standardize (Seiketsu)

- Establish schedules and standard instruction and procedures for all work.

## Sustain (Shitsuke)

- Create discipline to perform the first 4S practices, whereby everyone understand, obeys and practices the rules when in the plant. Implement mechanism to sustain the gains by involving people and recognizing them via performance measurement system.

## BENEFITS OF IMPLEMENTING 5S

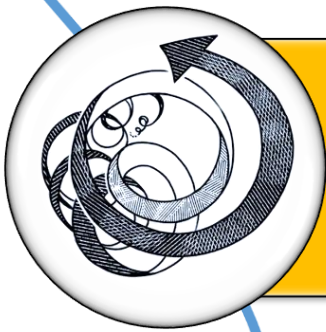


# PREVENTIVE MAINTENANCE

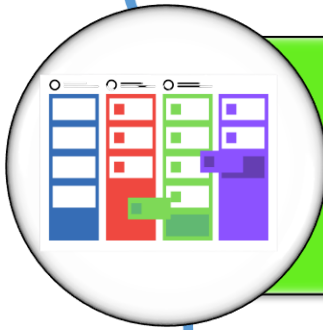
Because lean system have very little in-process inventory, equipment breakdowns can be extremely disruptive. To minimize breakdowns, companies use preventive maintenance programs, which emphasize in maintaining equipment in good operating condition and replacing parts that have tendency to fail before they fail.



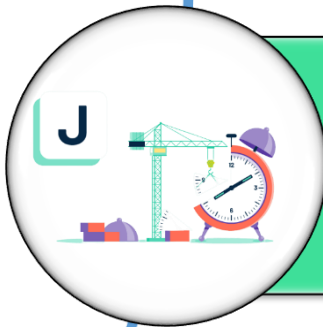
# CONTINUOUS IMPROVEMENT USING LEAN APPROACH



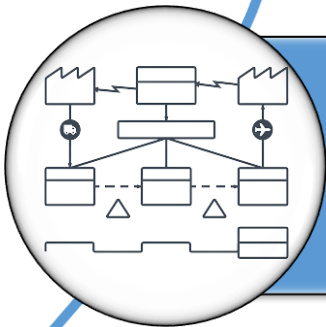
KAIZEN



KANBAN METHOD



JUST-IN-TIME (JIT)



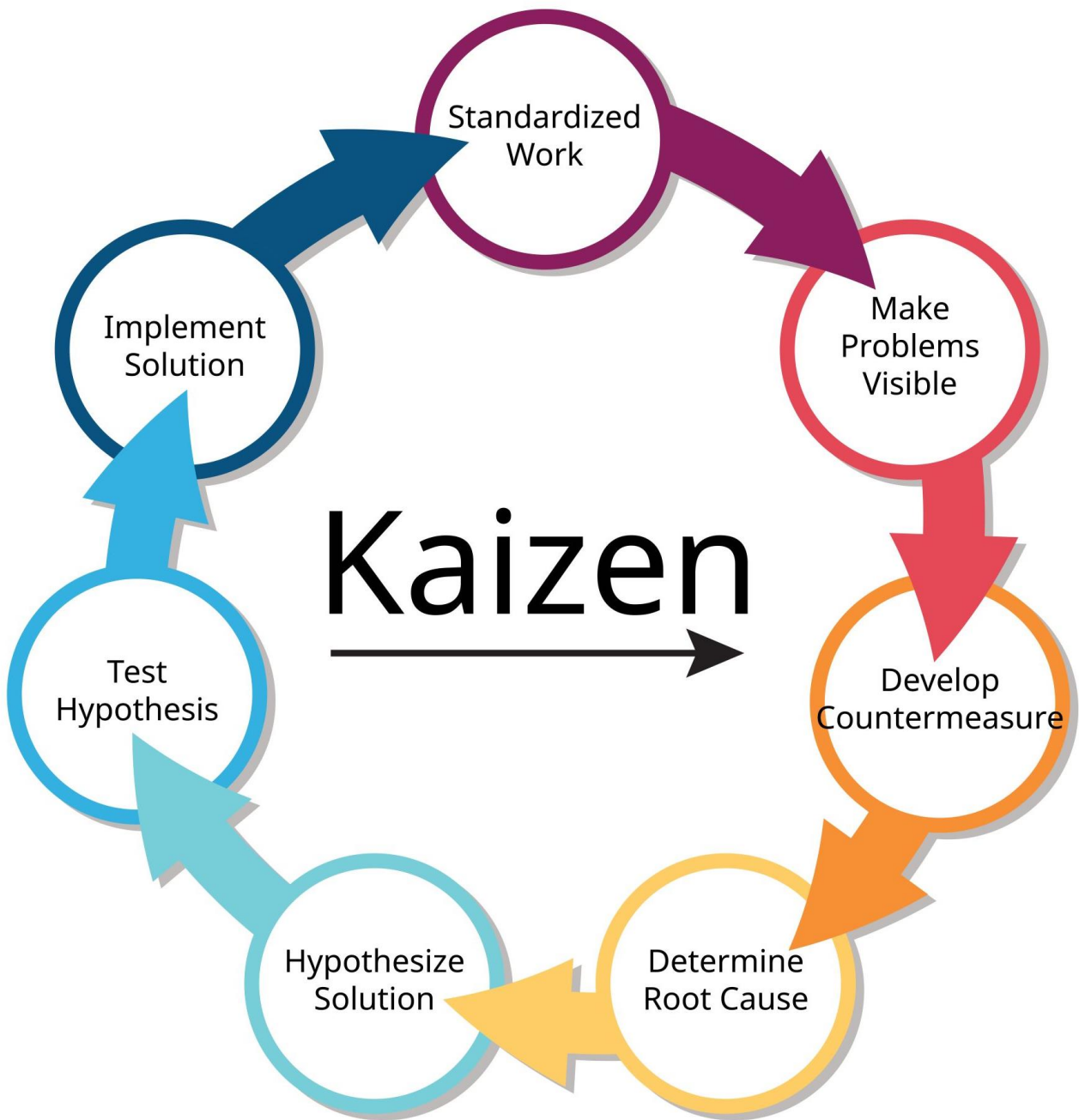
VALUE STREAM MAPPING (VSM)

## KAIZEN

- The word **Kaizen** derive from Japanese word that means gradual and orderly continuous improvement which involve everyone in the organization.
- Kaizen is a problem-solving technique by using existing resources.
- Kaizen is implemented by focusing on small, gradual, and frequent implements over the long term with minimum financial investment, and participation from everyone in the organization.
- Kaizen is based on following principles:
  - Work in team.
  - Focus on treating the root cause of inefficiencies.
  - Change and improvement – must be open for improvement and change in achieving a better way of doing things.
  - Old is comfortable but not efficient.
  - Do the right thing the first time.
  - Everyone in the organization must work together in doing kaizen.

KAI		ZEN			
改	+	善	=		
“change”		“good”			“good change” aka “continuous improvement”

# KAIZEN PROCESS DIAGRAM



# KANBAN METHOD

- **Kanban** is originally from the Japanese word meaning “**signal**” or **visible record**”.
- For instance, when the worker needs materials or work from preceding workstation, he or she will use kanban card which carries records of the system workflow or the work or materials.
- In kanban, the kanban card hold the authorization in order to move the works or materials.
- **Types of kanban:**
  1. **Production kanban (p-kanban)** : as a signal to produce parts.
  2. **Conveyance kanban (c-kanban)** : as delivering signal to deliver parts to the next work center.
- **General Operating Rules**
  1. Each container must have card.
  2. The assembly line always withdraws materials from fabrication (pull system).
  3. Containers of parts must never be removed from a storage area without a kanban being posted on the receiving post.
  4. The containers should always contain the same number of good parts. The use of non-standard containers or irregularly filled containers disrupt the production flow of the assembly line.
  5. Only non-defective parts should be passed along.
  6. Total production should not exceed the total amount of authorized on the kanban in the system,

# KANBAN METHOD

The number of Kanban card is an important variable. To compute the ideal number of kanban cards is by using the following formula:

$$N = \frac{D(T)(1 + X)}{C}$$

where,

N = total number of containers (1 card per container)

D = planned usage rate of using work center

T = average waiting time for replenishment of parts + average production time for a container of parts

X = policy variable set by management that reflects possible inefficiency in the system (the closer to 0, the more efficient the system)

C = capacity of a standard container (should be no more than 10% of daily usage of the part)

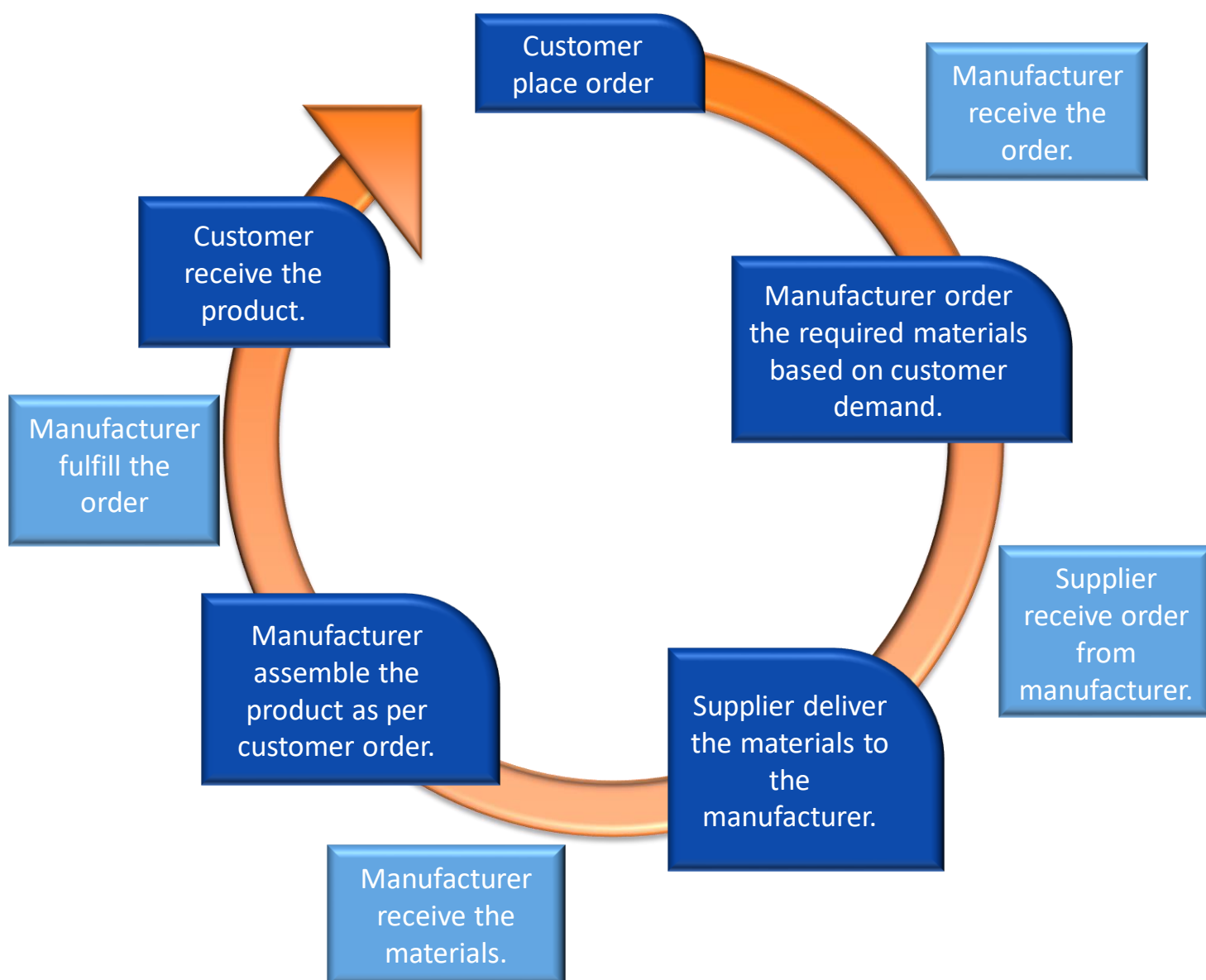
## EXAMPLE : Determining the Number of Kanban Cards Needed

Usage at a work center is 300 parts per day, and a standard container holds 25 parts. It takes an average of 0.12 day for container to complete a circuit from the time a kanban card is received until the container is returned empty. Compute the number of kanban cards (containers) needed if X = 0.20.

$$\begin{aligned} N &= \frac{D(T)(1 + X)}{C} \\ &= \frac{300(0.12)(1 + 0.20)}{25} \\ &= 1.728 \\ &\approx 2 \text{ containers} \end{aligned}$$

## JUST-IN-TIME (JIT)







Just-in-time is known as inventory control. By means, just-in-time occurred when the right amount of materials arrived at the right place at the right time - not too soon and not too late.





# VALUE STREAM MAPPING

Value stream mapping is a visual tool to systematically examine the flow of materials and information involved in bringing a product or service to a consumer. The technique is originated at Toyota, where it is referred to as “Material and Information Flow Mapping. The map is a sketch of an entire process that typically ranges from incoming goods from the suppliers to shipment of a product or delivery of a service to the

### Material Flow Icons

<p>Process Box</p> 	<p>Supplier/Customer (outside sources)</p> 	<p>Data Box</p> <table border="1" data-bbox="821 1019 976 1214"> <tr><td>Data Box</td></tr> <tr><td>C/T=</td></tr> <tr><td>C/O=</td></tr> <tr><td>Uptime =</td></tr> <tr><td>Shifts</td></tr> <tr><td>Avail. Time</td></tr> </table>	Data Box	C/T=	C/O=	Uptime =	Shifts	Avail. Time	<p>Inventory</p> 
Data Box									
C/T=									
C/O=									
Uptime =									
Shifts									
Avail. Time									
<p>Truck Shipment</p> 	<p>Movement of Material by PUSH</p> 	<p>Finished Goods to Customer</p> 							

### Information Flow Icons

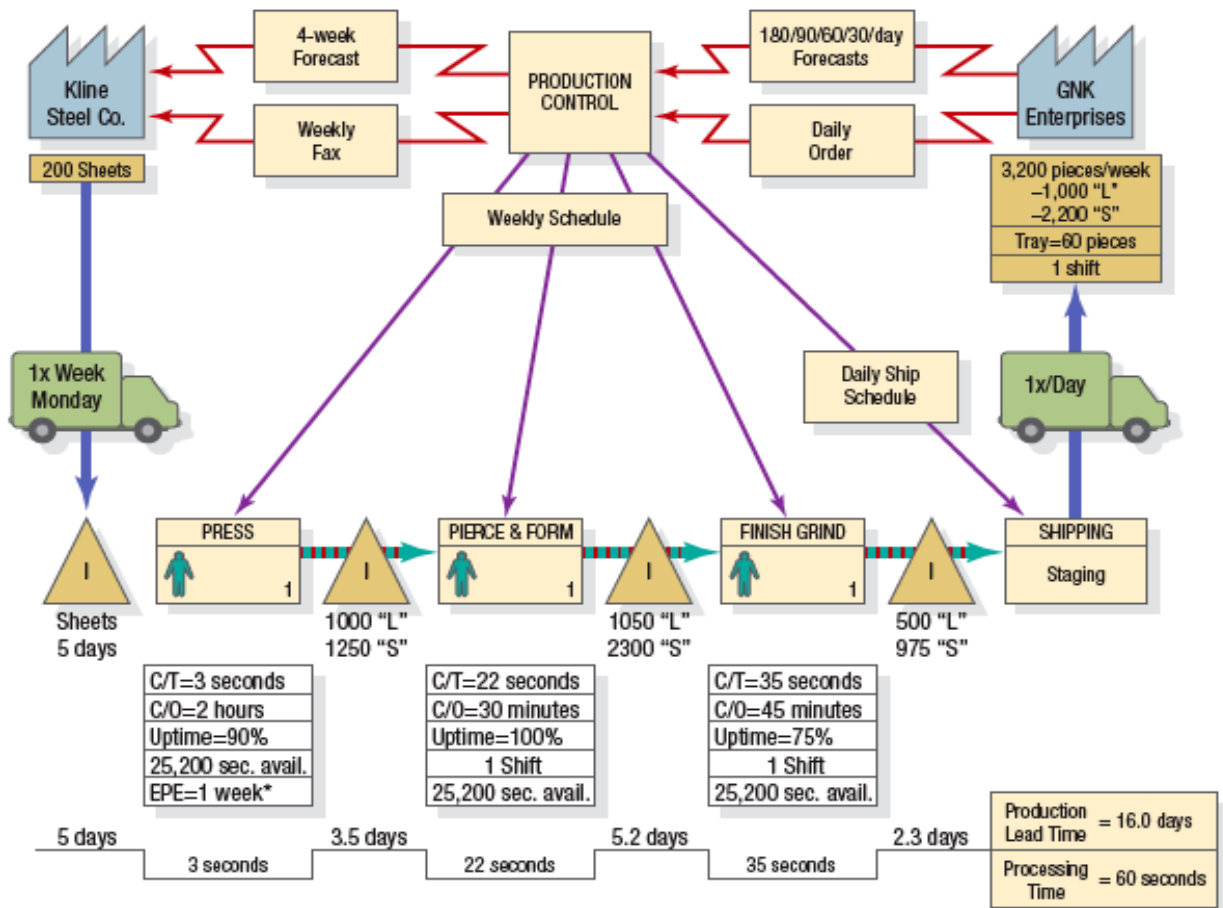
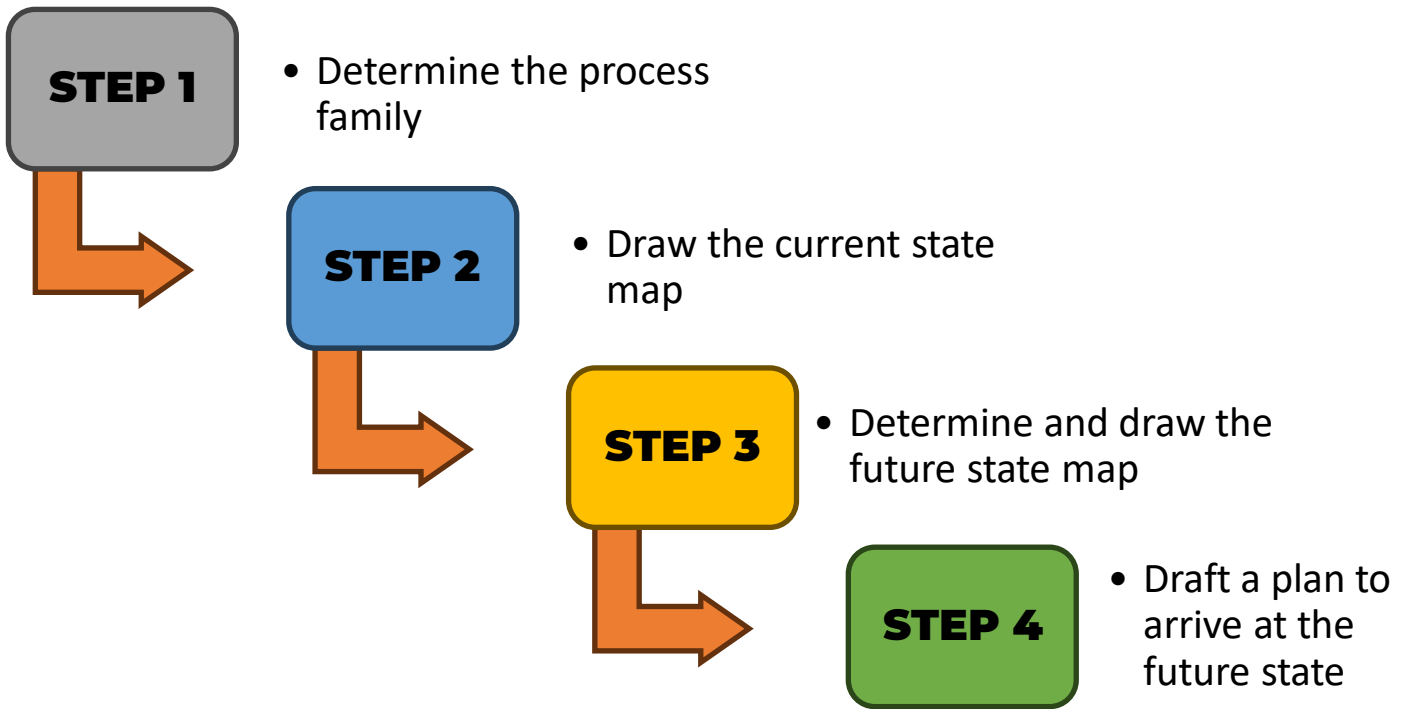
<p>Manual Information Flow</p> 	<p>Electronic Information Flow</p> 
--	--

### General Icons

<p>Operator</p> 
---

Value Stream Mapping (VSM) icons

# STEPS IN CONSTRUCTING VSM



Example Value Stream Mapping (VSM)

# BENEFITS AND RISKS OF LEAN SYSTEM



## Benefits

- Reduced waste due to emphasis on waste reduction.
- Lower cost due to reduced waste and lower inventories.
- Increased quality motivated by customer focus and the need for high quality processes.
- Reduced cycle time due to elimination of non-value-added operations.
- Increased flexibility due to quick changeovers and small lot sizes.
- Increased productivity due to elimination of non-value-added processes.



## Risks

- Increased stress on workers due to increase responsibilities for equipment changeovers, problem solving, and process and quality improvement.
- Fewer resources (e.g inventory, people, time) available if problem occurs.
- Supply chain disruptions can halt operation due to minimal inventory or time buffers.



# END OF CHAPTER 3 EXERCISE

1. Lean system always being apply in manufacturing industry, explain the lean tools as below:
  - i. Preventive maintenance
  - ii. Concept 5S
  
2. The following characteristics are present in an organization that has incorporated the lean principle into its production system. There are Pull Method, Quality at the Sources, Uniform Load, Small Lot Sizes, Standardized Component and Work Method, Close Supplier Ties, Flexible Workforce, Line Flow, 5S, Automation, and Total Preventive Maintenance. Figure how these characteristics operates.
  - i. Standardize Component and Work Method
  - ii. Close Supplier Ties
  - iii. Flexible Workforce
  
3. Waste is any activity for which the customer will not be willing to pay, the opposite value. Explain waste in manufacturing.
  
4. Kanban is a scheduling system that is used in lean processes. As an assistant engineer, you need to examine TWO (2) core principles of Kanban system to help the company to increase production and reduce inventories.
  
5. The top management of your company is considering to do floor marking for 5S project to improve workplace efficiency and eliminate waste. You are required to analyze and propose the best practice based on 5S element.



# SUGGESTED ANSWERS



# Bibliografi

C J P Zaalberg, et al. *The Manufacturing Industry*. New Haven, Yale University Press, For The Carnegie Endowment For International Peace, Division Of Economics And History, 1928.

Grant, David B, et al. *Sustainable Logistics and Supply Chain Management : Principles and Practices for Sustainable Operations and Management*. New York, Kogan Page Ltd, 2017.

Groover, Mikell P. *Fundamentals of Modern Manufacturing : Materials, Processes, and Systems*. Hoboken, Nj, John Wiley & Sons, Inc, 2020.

Heizer, Jay, et al. *Operations Management : Sustainability and Supply Chain Management*. North York, Ontario, Pearson, 2020.

Nelson, Donald H, and George Schneider. *Applied Manufacturing Process Planning : With Emphasis on Metal Forming and Machining*. Upper Saddle River, N.J., Prentice Hall, 2001.

Niebel, Benjamin W, et al. *Modern Manufacturing Process Engineering*. New York, Mcgraw-Hill, 1989.

Rastogi, M K. *Production and Operation Management*. Laxmi Publications, 2010.

# THANK YOU



*Diploma in  
Manufacturing  
Engineering,*

*Mechanical Engineering  
Department*

*Polytechnic Port Dickson*



# **MANUFACTURING SYSTEM VOL . 1**



**Manufacturing system Vol. 1**

**e ISBN 978-967-2897-98-9**



**POLITEKNIK PORT DICKSON**

**(online)**