Lean Operations: Introduction to Toyota Production System, MUDA (8 type of Waste), MURI, MURA

Dr. Aditya Kumar Sahu

IIM Rohtak

Why a Firm exists?

- To create VALUE

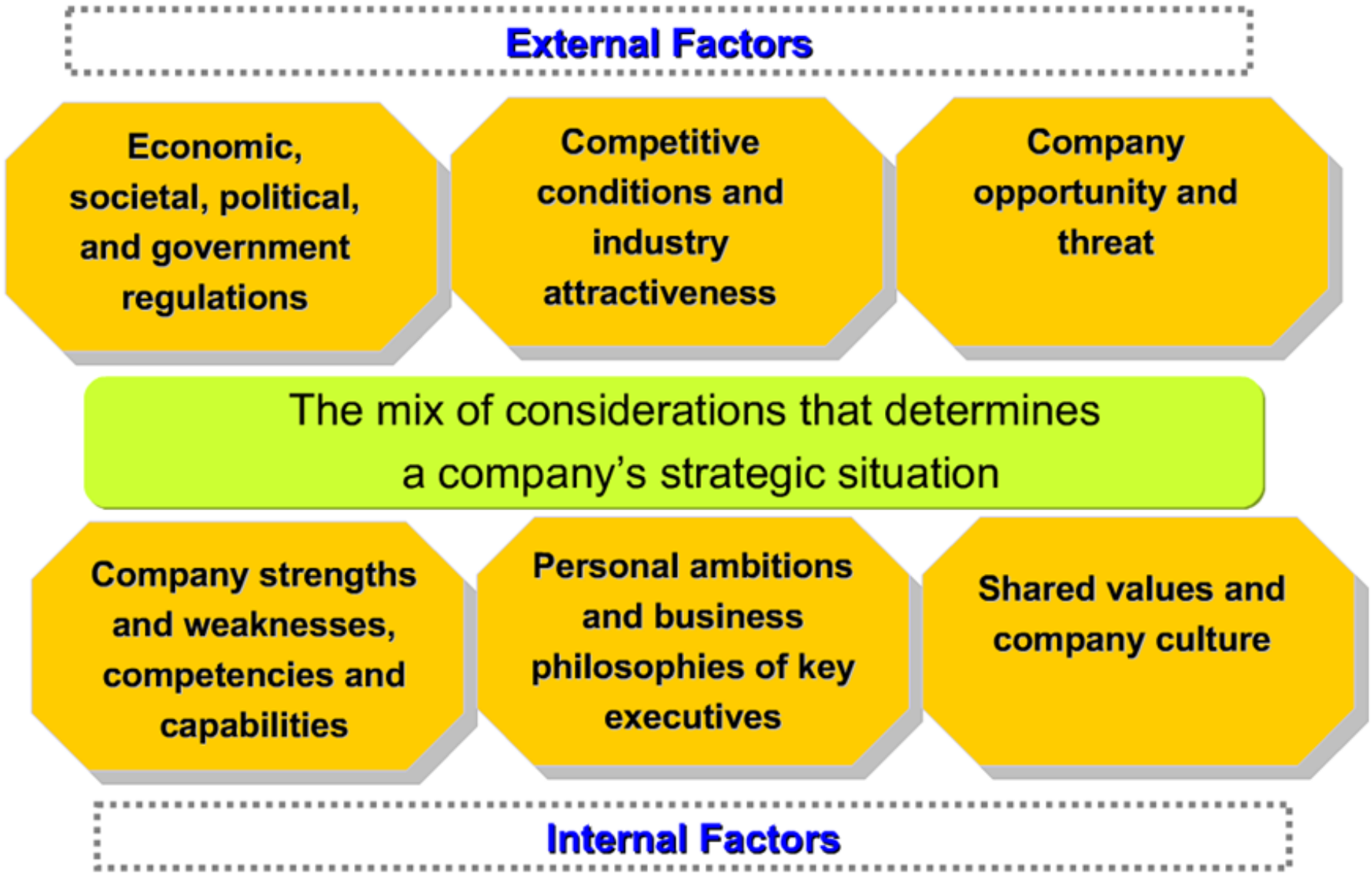
  - Value for Customers
  - Value for Employees
  - Value for Supplier

Two Major Dimensions of Management:

1. Responds to changes in the **external environment** and allocates the firm's scare resources to improve its competitive position.

2. **Internal responses** to new action programs aimed at enhancing the competitive position of the firm.

Factors shaping choice of strategy



Top 10 companies in the world in 2006:

1.Exxon Mobil
2.General Electric
3.Microsoft
4.Citigroup
5.BP
6.Royal Dutch Shell
7.Pfizer
8.Toyota
9.IBM
10.Procter & Gamble

Top 10 companies in the world in 2022:

1. Apple Inc.
2. Microsoft Corporation
3. Alphabet Inc. (Google)
4. Amazon.com Inc.
5. Meta Platforms Inc. (formerly Facebook)
6. Nvidia Corporation
7. Tesla Inc.
8. Berkshire Hathaway Inc.
9. TSMC (Taiwan Semiconductor Manufacturing Company)
10. Visa Inc.

Lesson from Failure

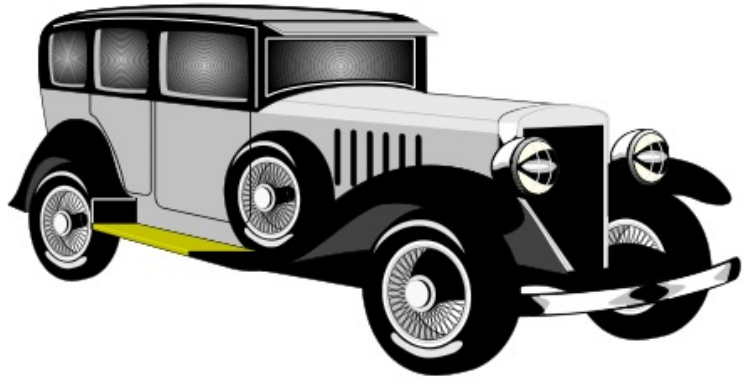
- To continuously improve

Discussion Points

- About TPS
- TPS to Lean
- Lean Principles
- Lean Tools

CRAFT Manufacturing

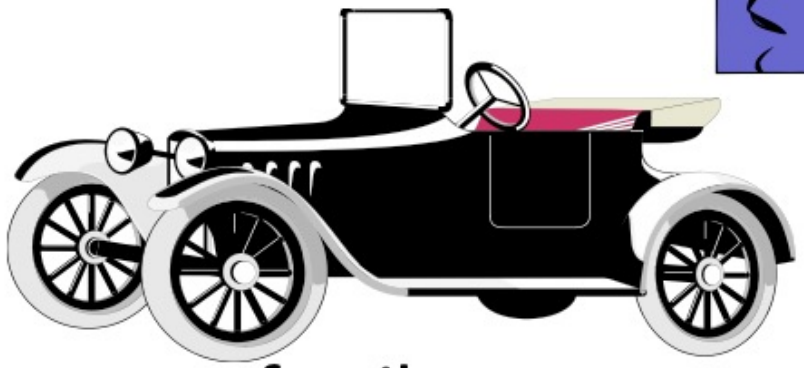
- Late 1800's
- Car built on blocks in the barn as workers walked around the car.
- Built by craftsmen with pride
- Components hand-crafted, hand-fitted
- Excellent quality
- Very expensive
- Few produced



More than 100s of companies in Western Europe and North America. Each made fewer than 1000 a year, rarely made 50 from a single design.

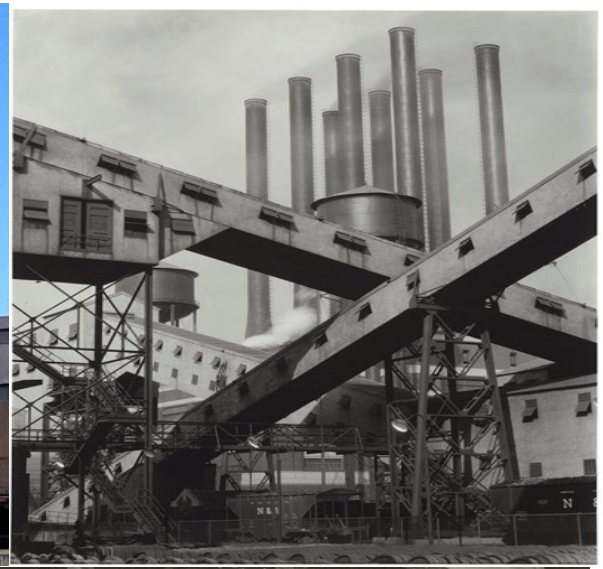
Mass Manufacturing

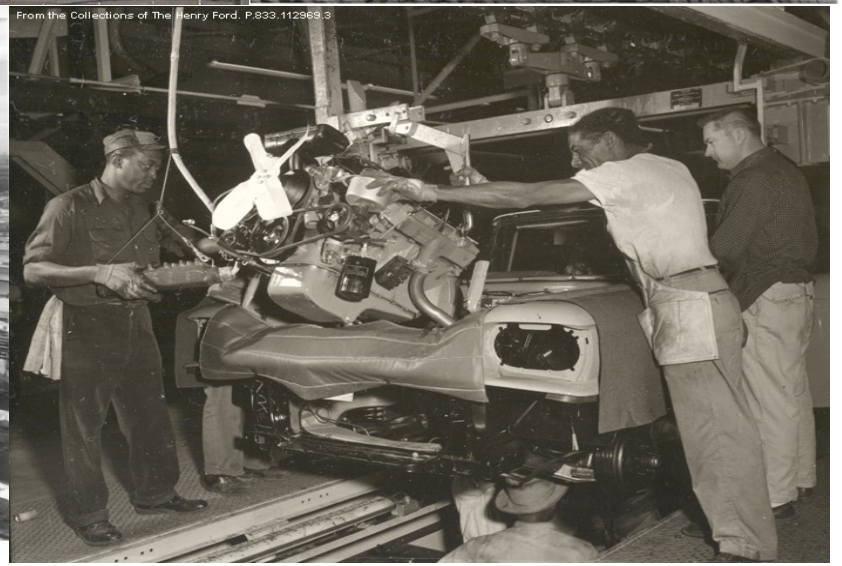
- Assembly line - Henry Ford 1920s
- Low skilled labor, simplistic jobs, no pride in work
- Interchangeable parts
- Lower quality
- Affordably priced for the average family
- Billions produced - identical



1920's to 1927 Ford only produced Model T.
One end raw material …other end rolled cars 7000 /day
(Ford River Rouge Plant)

Ford River Rouge plant near Detroit





History of Japan Auto Sector

- Combination of Craft and Mass Production
- World War II

Emergence of Toyota Production System (TPS)

History of Japan Auto Sector

- 1927-1935: Big 3 of US (Ford, GM, Chrysler) produced 208,967 vehicles (domestic production 12,127 vehicles)
- 1937: Toyota Motor Company Established (CEO Kiichiro Toyoda)
- 1940: Toyota's productivity was estimated to be roughly one-tenth of the major U.S. makers
- 1950: Facing the threat of bankruptcy
- Kiichiro Toyoda resigned as CEO

Eiji Toyoda: Visited Ford River Rouge plant in early 1950's

- Eiji Toyoda (born -1913) was the former chairman of Toyota motors co.
- For over 25 years he was in the driver seat of Toyota motor co.
- After his retirement he continue to hold the title of the honorary chair of the company.

It is easy to make money when everyone is making money.
The key is to be able to make money when times are bad.

-Eji Toyoda

Taiichi Ohno: Principle founder TPS, visited Detroit

CONSTRAINTS FOR TOYOTA AND IMPLICATIONS

Taichi Ohno's observation :

- Shortage of capital for equipment/facilities
  - Cannot afford specialized equipment

- Shortage of markets to serve
  - Must be able to produce a variety of products in the same facility

- Shortage of workers and other resources
  - Must employ workers able to do a variety of different tasks

Constraints for Toyota: Emergence of TPS

- Shortage of capital for equipment/facilities
- Cannot afford specialized equipment
    - *Must be able to use in a variety of ways*
    - **Quick changeover procedures; flexible layout**

- Shortage of markets to serve
    - *Must be able to produce a variety of products in the same facility*
        - **Small batch production; mixed model production**

- Shortage of workers
    - *Workers must be able to do a variety of tasks*
        - **Employee involvement**
    - *Processes cannot be wasteful*
        - **Pull production, standard operations, TPM**
        - *Because of these shortages, emphasis on*
        - **Elimination of waste (Seven Mudas), continuous improvement (Kaizen)**

Eiji Toyoda….

- Problems are rolling all around in front of your eyes, whether you pick them up and treat them as problems is a matter of habit. If you have the habit, then you can do whatever you have a mind to

- One of the features of the Japanese workers is that they use their brains as well as their hands

- Our workers provide 1.5 million suggestions a year, and 95 percent of them are put to practical use. There is an almost tangible concern for improvement in the air at Toyota.

Criticism By the Communist Party Against T P S

….the Toyota Motor Company, Ltd. has earned the current profit of 210 billion yen (about $1 billion). Behind this huge profit how many subcontractors have dropped tears? Toyota's completely rationalized production system strictly instructs its subcontractors to deliver the required parts within today or by tomorrow. Therefore, there is no excessive parts inventory at Toyota….

….serious matter which cannot go unnoticed is that this Toyota system is now prevailing among many industries and a vast number of subcontractors are likely to fall victims to this system. If this practice of bullying the subcontractors is left unrestricted, the Japanese economy will be thrown into chaos….

-(Proceedings at the Japanese House of Representatives, No.4: October 7, 1977, p. 63.)

Core of TPS..

On Feb 24, 2010, Mr Akio Toyoda, President of Toyota Motors testified by US House of Representatives Committee on Oversight and Govt. Reform :

"…..In the name of the company , its long standing tradition and pride , we never run away from our problems or pretend we do not notice them. By making continuous improvements, we aim to continue offering even better products for society. That is the core value we have kept closest to our heart…"

…at Toyota , we believe that the key to making quality products is to develop quality people…

Eiji Toyoda in 1985 at the company's joint factory with General Motors, known as Nummi.

Sept. 12, 1913, - Sept, 16, 2013

Lean Manufacturing Since 1980's

- Cells or flexible assembly lines
- Broader jobs, highly skilled workers, proud of product
- Interchangeable parts, even more variety
- Excellent quality mandatory
- Costs being decreased through process improvements.
- Global markets and competition.

History

Era	Volume	Variety	Quality	Price	Lead time
Craft Manufacturing (after 1800's)	Low	Low	Good	High	High (Almost 1 year)
Mass Manufacturing (Pre WW-II Era) Till 1960s	High	Low to Medium	Average	Medium	Medium (Almost 6 months)
Lean Manufacturing (since 1980s)	Low	High	Excellent	Low	Just It Time

- https://www.youtube.com/watch?v=F5vtCRFRAK0&ab_channel=BloombergOriginals

History of the word “Lean”

Field Work: Completed visits to 70 assembly plants worldwide between 1986 and 1989 (usually involved three different visits)

Findings:

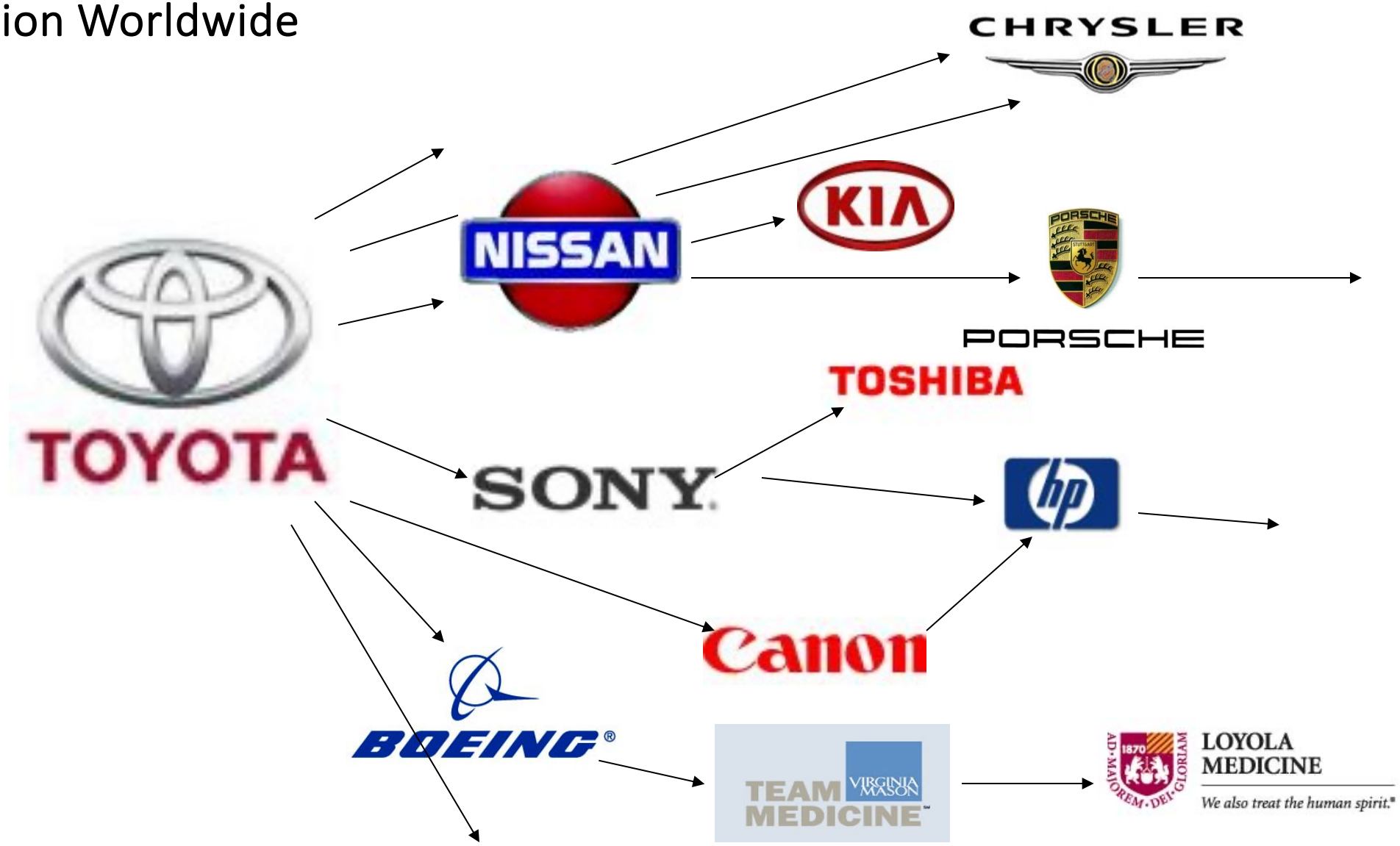
- Production management policies has tremendous effect on plant performance. Some North American plants has achieved the efficiency level of Japanese plant with lean production policy.
- Lean plants can achieve better quality, productivity and complexity.
- Corporate parentage and culture are as important while checking plant performance.
- Level of technology has little effect on performance.
- Lean management policy can improve productivity and quality performance but has inherent risks that can be managed with discipline, skills, proper training, flexible workforce.(Introduced the term *Lean)*

(Source : Krafcik, John F (1988) Triumph of the Lean Production System

XPS

Alfa Laval Production System (ALPS)	Ecco Production System (EPS)
Audi Produktions system (APS)	Electrolux Manufacturing System (EMS)
Bosch Production System (BSP)	JCB Production System
Aluminium Metal Production System (AMPS)	LEGO Production System (LPS)
John Deere Quality and Production System	Mercedes Production System(MPS
Volvo Production System(VPS)	Whirlpool Production System (WPS)
Boeing Production System (BPS)	Caterpillar Production System (CPS)

Just-in-Time/Lean Production Diffusion Worldwide



Definition of Lean?

Definition of Lean

- Lean is a management philosophy focused on improving productivity by identifying and eliminating waste throughout a product's entire value stream, extending not only within the organization but also along the company's supply chain network.

- A systematic approach to identifying and eliminating waste (non-value-added activities) through continuous improvement by flowing the product through flow processes based on a signal from the customer.
- Thus, increasing customer satisfaction.

PRINCIPLES OF LEAN

VALUE?

VALUE

Defn: Value is the inherent worth of a product as judged by the customer and reflected in its selling price and market demand".

For an activity to be considered value added, it must meet three criteria:

1. The customer must be willing to pay for the activity.

2. The activity must transform the product or service in some way.

3. The activity must be done correctly the first time.

SPECIFY VALUE

- **What can I do to improve my teaching in every class and every course?**
- **How can I improve students' learning experience so that they will actually apply in the real world what they learned in the classroom?"**
- **How you create value for your customer?**

VALUE STREAM

Whenever there is a product for a customer , there is a value stream, the challenge lies in seeing it….John Shook

VALUE STREAM

- All of the actions, both value-creating and non value-creating, required to bring a product from concept to launch (also known as the development value stream) and from order to delivery (also known as the operational value stream).

- These include actions to process information from the customer and actions to transform the product on its way to the customer.

Tool: Value Stream Mapping

- Value stream mapping is a method for documenting business processes, allowing project managers and analysts to analyze the different states and identify areas of improvement

.

- Every business has processes for making and selling products and services. The more you know about those processes, the more effectively you can manage and improve them.

FLOW

……out of all secrets of the river, he today only saw one, this one touched his soul. He saw: this water ran and ran, incessantly it ran, and was nevertheless always there, was always at all times the same and yet new in every moment!....

Hermann Hesse, Siddhartha

FLOW

Make products flow is the third pillar of lean thinking and involves keeping materials and information moving so that materials ‘flow’ to customers without delay or interruption.

“WHY DO WE STRIVE TO CREATE FLOW?”

“*We strive to create flow because it is most efficient way to produce?”*

PULL

The universe demands balance.

PULL

Pull production at the rate of consumption is used when it is not possible to complete flow products to customers (due to the number of customers, short lead times, the needs of your technology and batch sizes or other constraints).

PERFECTION

When you aim for perfection, you discover it is a moving target.

G.F Fisher

PERFECTION

Pursue perfection in all processes. Global competition is a brutal "race without a finish line," requiring continuous improvements of processes and products

Mutual Respect

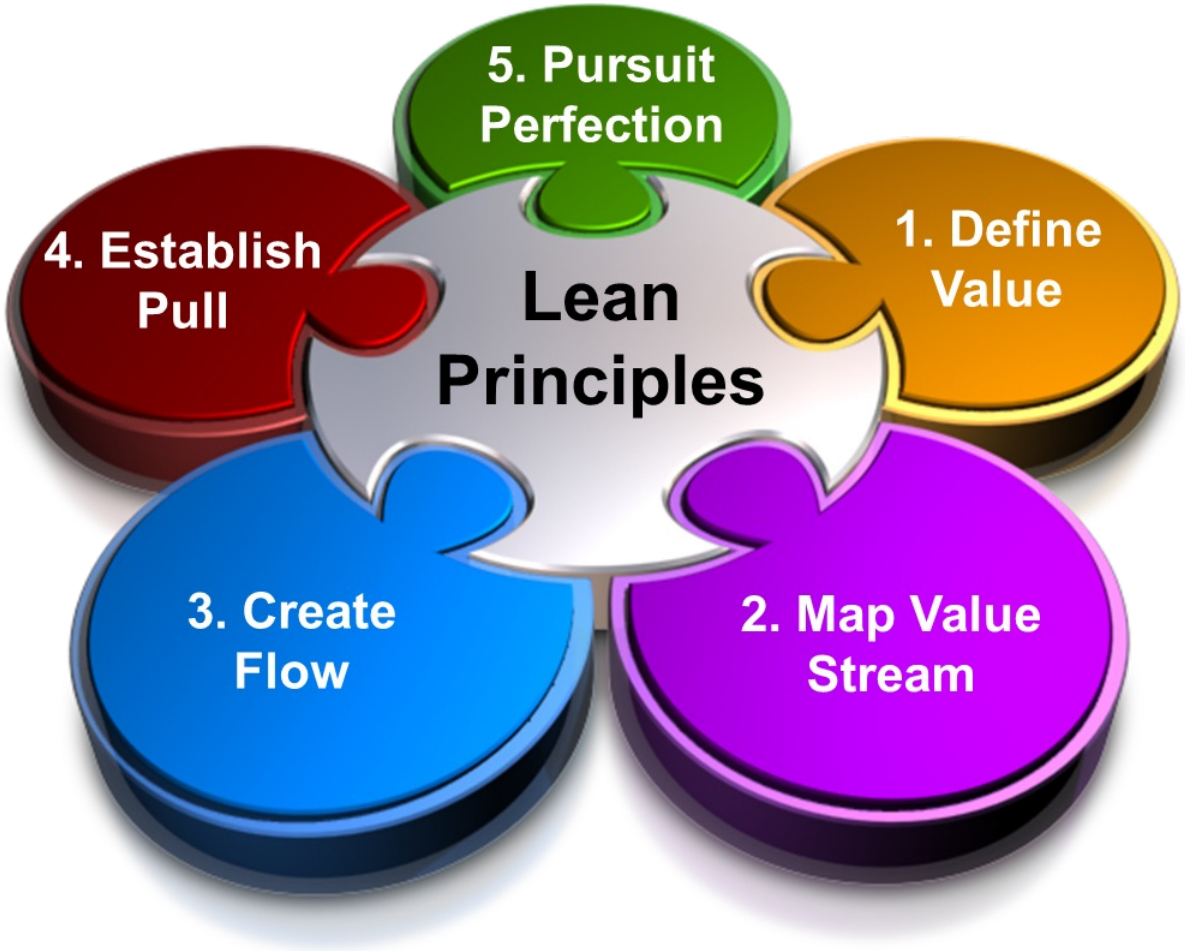
Sangchhadhwam Sanvadadhwam Sam Vo Manasi Janatam |
Deva Bhagam Yatha Purve Sanjanana Upasate (Rigveda)

Come together! Speak together! Let our minds be all of one accord just as the ancient gods sat together in harmony. That is why they are worshipped.

MUTUAL RESPECT

People are most important resources …

LEAN PRINCIPLES



Lean Principles

- **Principle 1: Define Value**

Capture the value defined by the customer stakeholders

- **Principle 2: Map Value Stream**

Map the value stream (plan the program) and eliminate waste

- **Principle 3: Create Flow**

Flow the work through planned and streamlined value adding steps and processes

- **Principle 4: Establish Pull**

Let customer, stakeholders pull value

- **Principe 5: Pursuit Perfection**

Pursue perfection in all processes

- **Principle 6: Respect people**

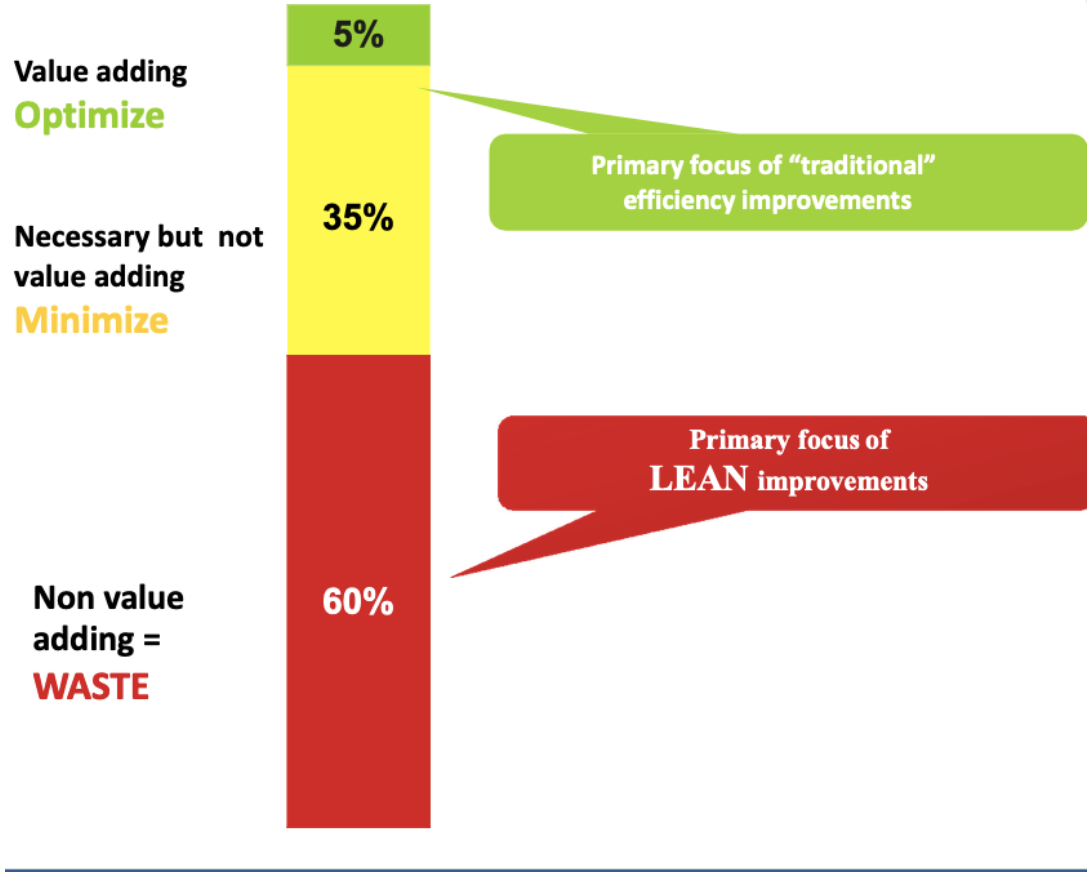
Respect the people in your work places

Summary

- Value added (VA): Activities are classified as value added as long as the customer is willing to pay for that activity
- Non-value added (NVA): All those activities for which the customer may not want to pay are classified as non-value added activities
- Necessary but non-value added (NNVA): the set of activities that are to be eventually eliminated as and when better systems are developed in an organization
- Waste: Any process or a set of activities that do not add value as perceived by the customer
- Value stream: All activities that need to be performed (VA and NNVA) from the time the customer order is received to the time the order is fulfilled will make up the value stream

- Lean Management: Process by which continuous efforts of all concerned parties enables an organization to create a channel for the value stream by eliminating waste from the system

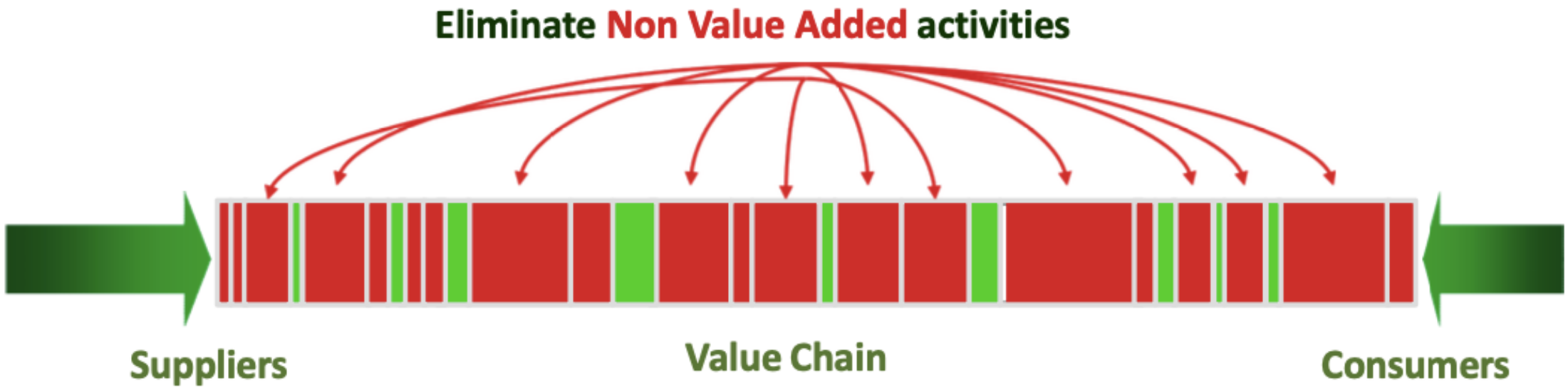
- **LEAN is all about improving Throughput Time**



Criteria for Comparison	Japan@	U.S.*
Production of Vehicles (Million)	4	8
Number of employees	37,000	850,000
Parts on which detailed engineering is done	30%	81%
Number of employees in Purchasing	337	6,000
Number of suppliers for upholstery	1#	25**

Based on the data available in Womack, J.P., Jones, D.T. and Roos, D. (1990), "The Machine that changed the world", Rawson Associates.

Eliminating Waste



Reduce Lead Time

Higher flexibility	Reduced stocks	Better Service	Reduced Complexity	Less cost	Revived Freshness

Look at this Company, Process & Activities....

Class Exercise

- **What are the Common Sources of Waste in your company and Industry in general?**

Common Sources of Waste

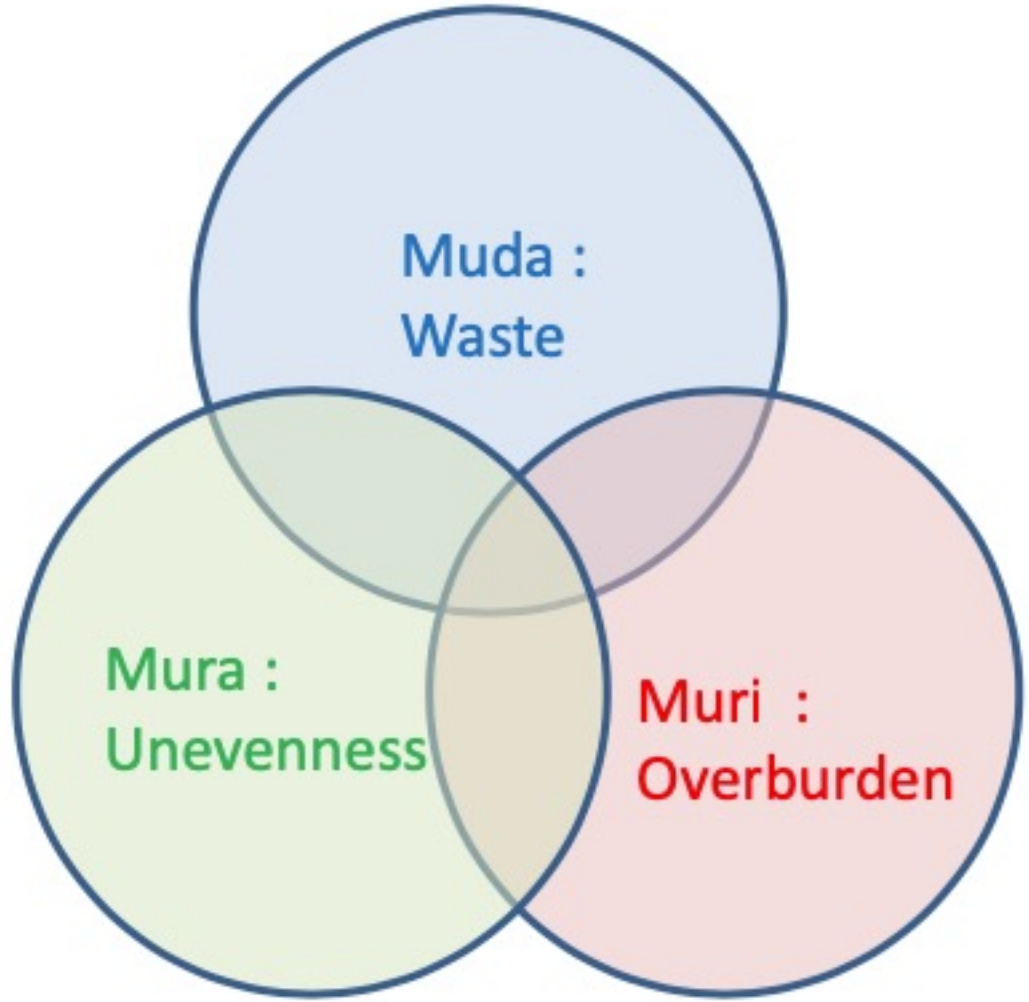
Category	Manufacturing Organizations	Service Organizations
Inventory Related Waste	• Accumulating Inventory • Waiting for material to work on • Stock verification • Counting the number of parts • Temporary Storage • Parts Shortage	• Overflowing “In Baskets” • Duplication of work • Too much of paper work • Incomplete information leading to pending decisions
Waste Due to Processes	• Defects & Rework • Machine Breakdowns • Watching the machine run	• Payments not made on time • Wrong service delivery (Service Failure) • Proposals not completed on time for the bid • Customer Orders taking too long to be filled
Waste Due to Planning	• Looking for tools • Carrying heavy pieces • Transferring parts over long distances • Over Production & Double Handling	• Complicated office layouts • Poorly planned meetings • Documents handled many times before a decision is taken • Extra signature needed that hold up completion • Teams with incomplete or no direction.

Types of problems

MUDA :
Anything that is non value adding is waste. There are typically 8 types of waste. Waste has negative effect on time, efforts, energy and money.

MURA :
Unevenness results from an irregular production schedule, or fluctuating production volumes due to internal problems like down time, missing parts or defects.

MURI :
Muri is overburdening people or equipment beyond natural limits. Overburdening people results in safety and quality problems. Overburdening equipment results in breakdowns and defects.



3 Ms of Lean

Muri = overburdened

Mura = unevenness, fluctuation, variation

Muda = waste

No Muri, Mura, or Muda

Muri – Overburden

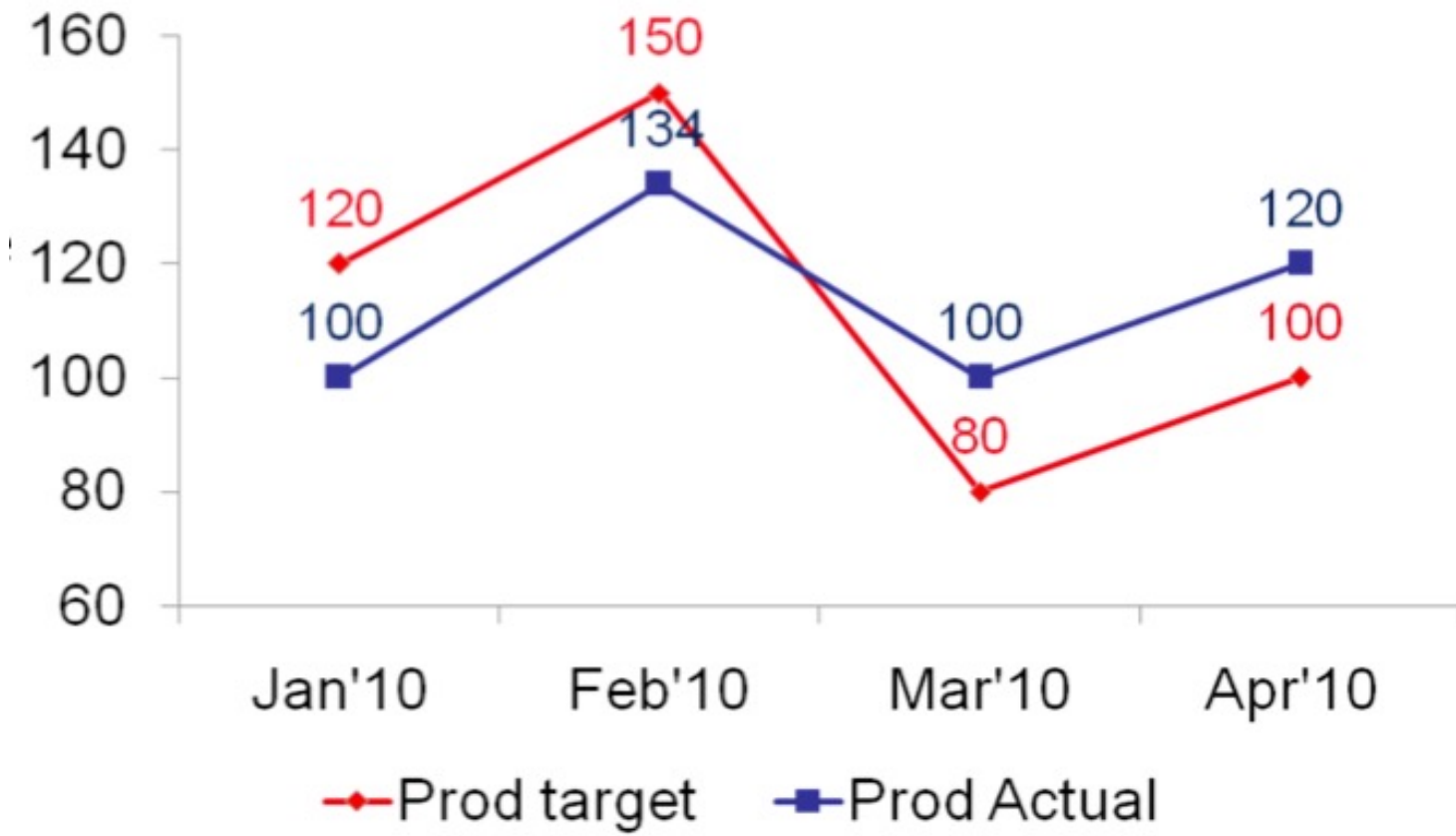
MURI

Overburden means going beyond one's natural limits.
e.g.
Bottleneck machine has more work.
Capable person gets more responsibilities.

Mura – variation

MURA

Nothing remains constant.
Everything changes.
Variation creates situations leading to waste or overburden.
e.g.
Continuously Changing production targets, causes either shortages or overproduction.



Toyota’s Seven Waste

- Transportation
- Inventory
- Motion
- Waiting Time
- Overproduction
- Over Processing
- Defects

(T I M W O O D)

Overproduction

Waiting

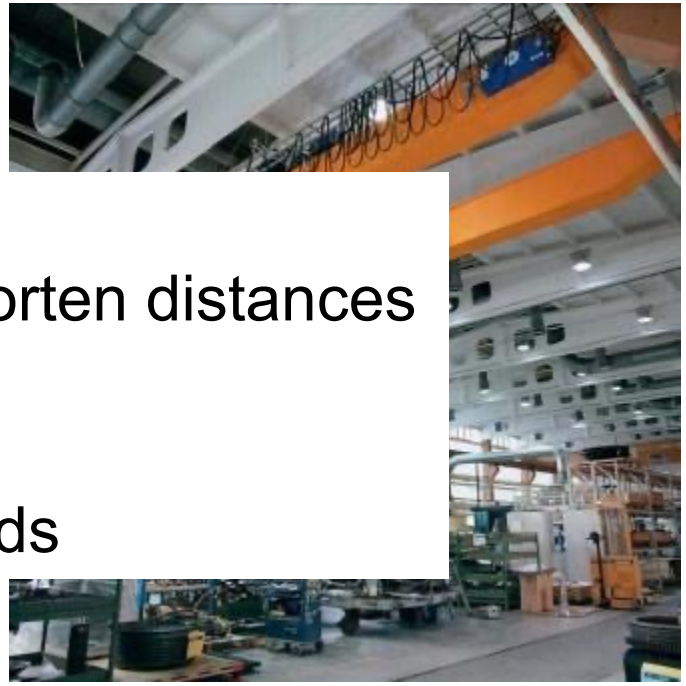
Waiting

Eliminate *sources* of waiting

- Setup time
- Equipment breakdown
- Erratic schedules
- Large-batch production
- Defects

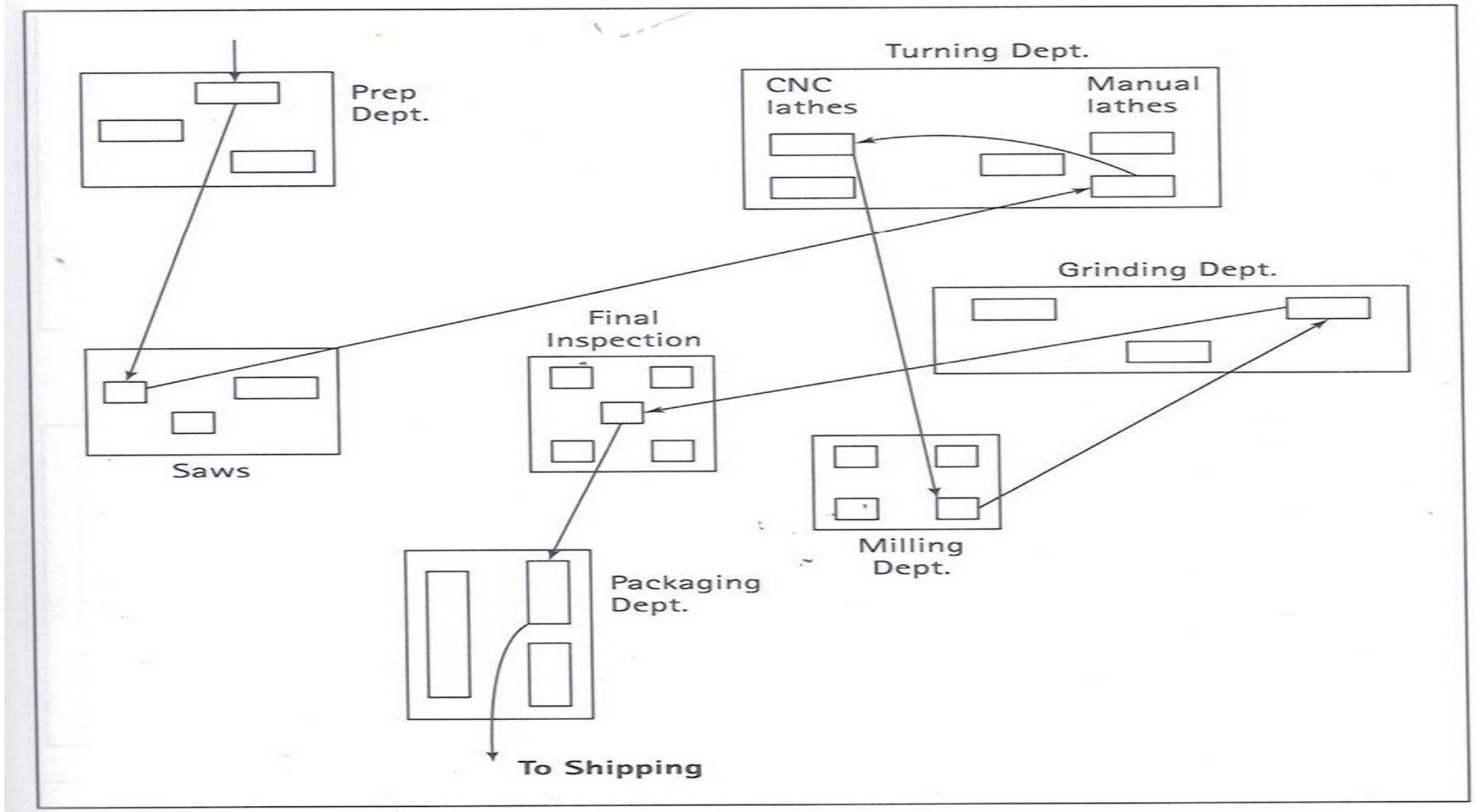
Transportation

Transportation

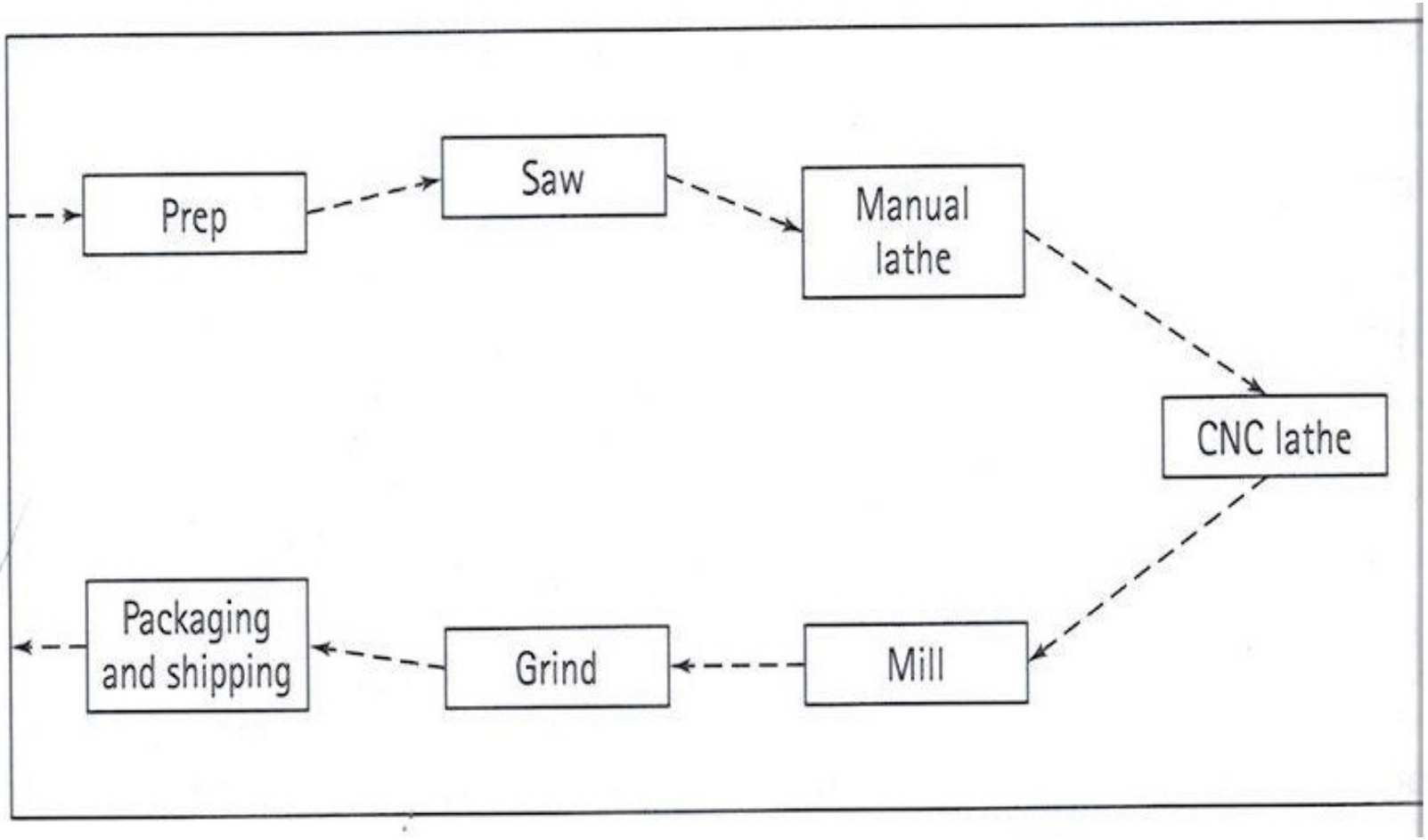


Solutions:

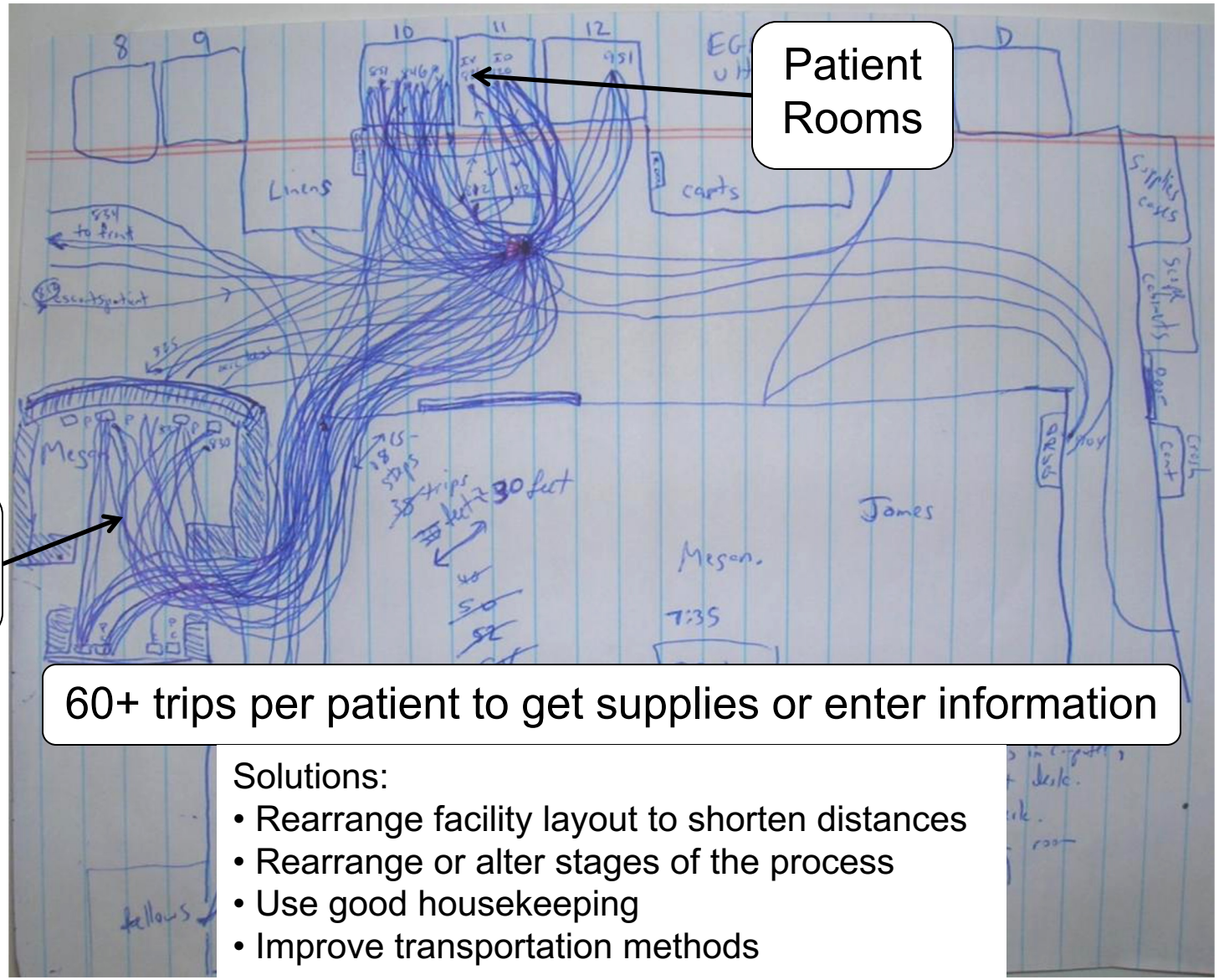
- Rearrange facility layout to shorten distances
- Coordinate stages of process
- Use good housekeeping
- Improve transportation methods


Prep
Dept.
Turning Dept.
CNC
lathes
Manual
lathes
Grinding Dept.
Final
Inspection
Saws
Milling
Dept.
Packaging
Dept.
To Shipping

Proposed Layout



Spaghetti Chart



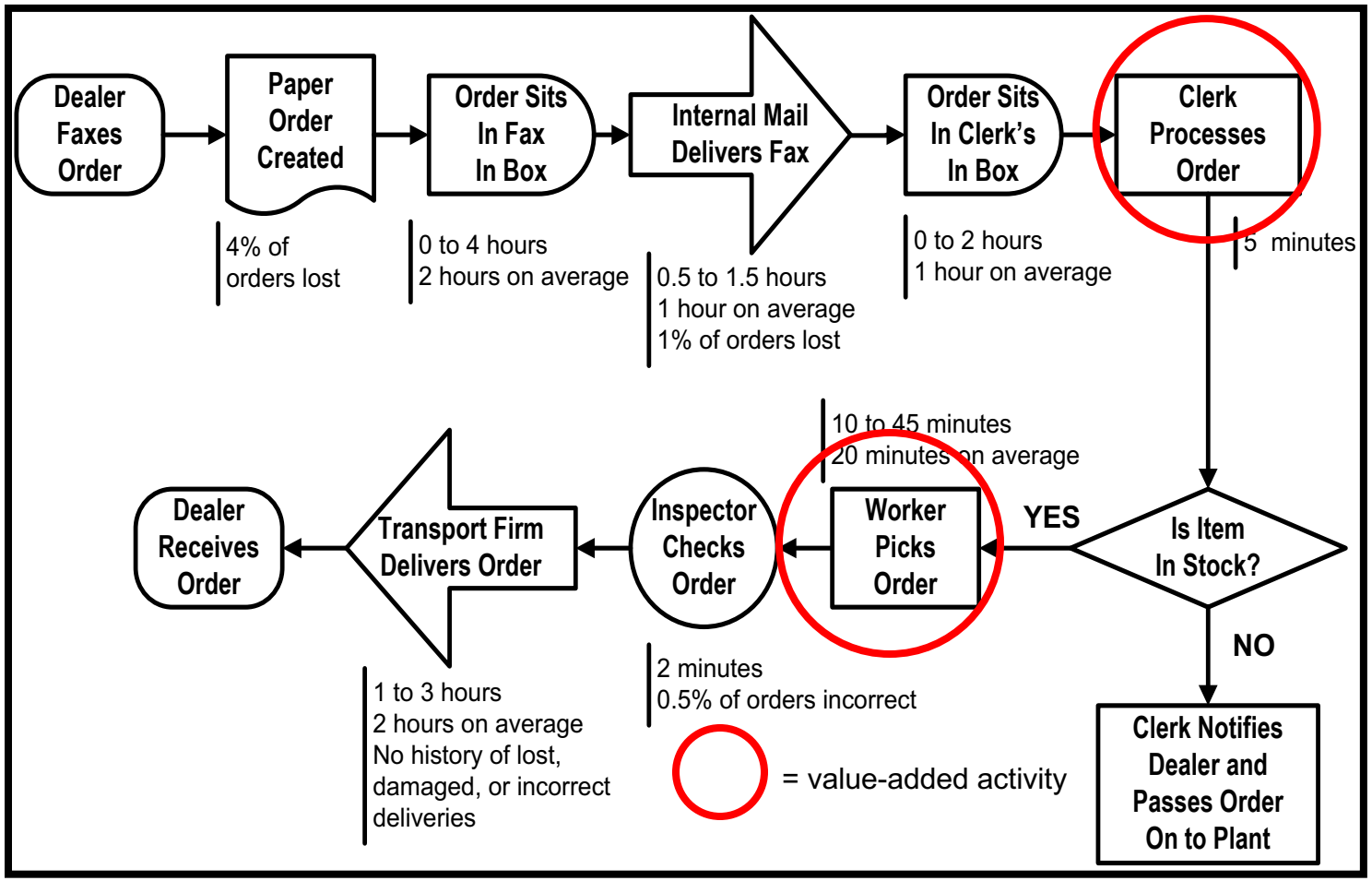
Solutions:

- Rearrange facility layout to shorten distances
- Rearrange or alter stages of the process
- Use good housekeeping
- Improve transportation methods

Processing

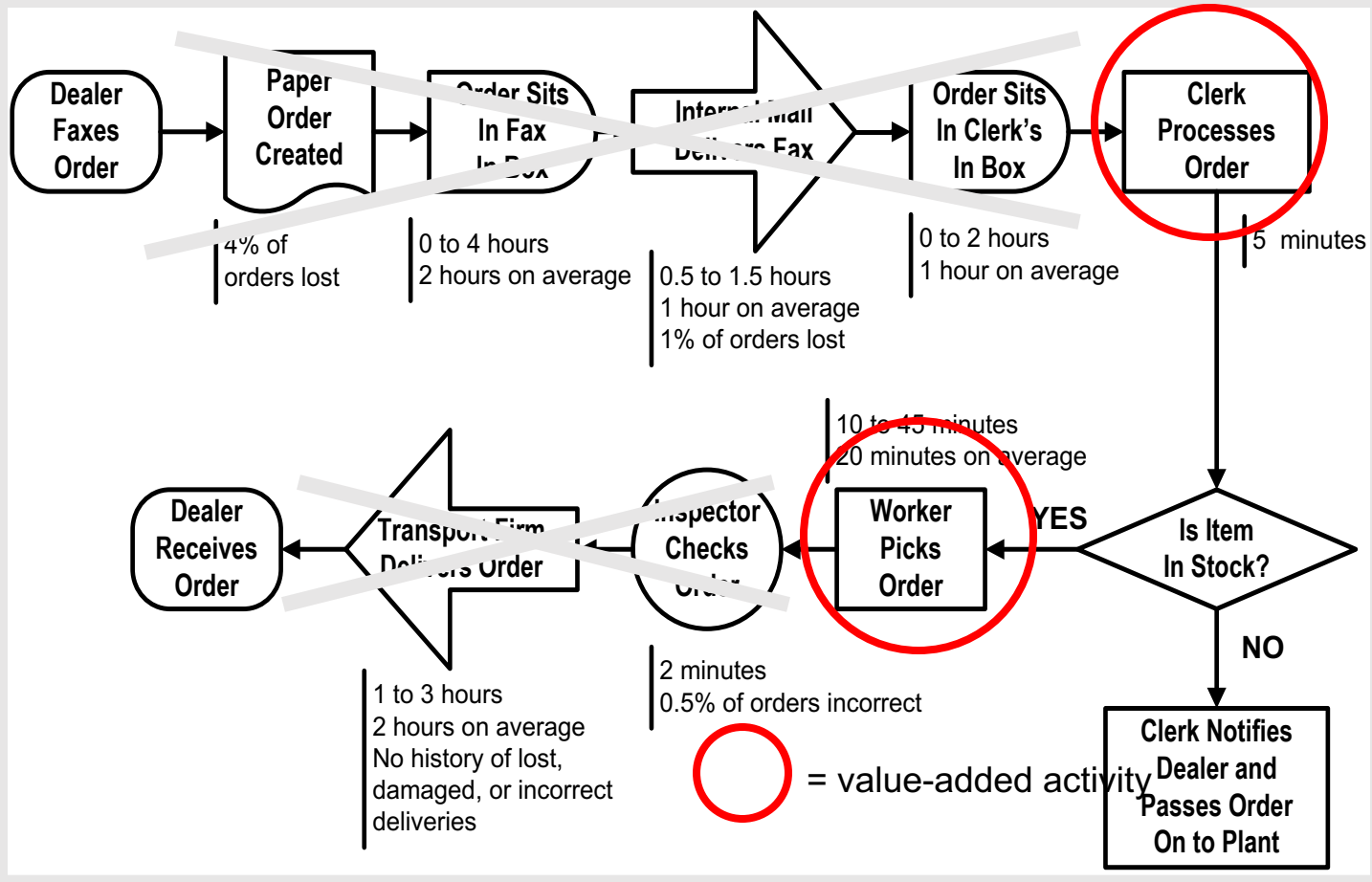
A process may itself contain steps that are ineffective or unnecessary .Opportunity in Manufacturing and servicing as well.

Processing


Dealer Faxes Order
Paper Order Created
Order Sits In Fax In Box
Internal Mail Delivers Fax
Order Sits In Clerk's In Box
Clerk Processes Order
4% of orders lost
0 to 4 hours
2 hours on average
0.5 to 1.5 hours
1 hour on average
1% of orders lost
0 to 2 hours
1 hour on average
5 minutes
10 to 45 minutes
20 minutes on average
Dealer Receives Order
Transport Firm Delivers Order
Inspector Checks Order
Worker Picks Order
YES
Is Item In Stock?
NO
1 to 3 hours
2 hours on average
No history of lost, damaged, or incorrect deliveries
2 minutes
0.5% of orders incorrect
= value-added activity
Clerk Notifies Dealer and Passes Order On to Plant

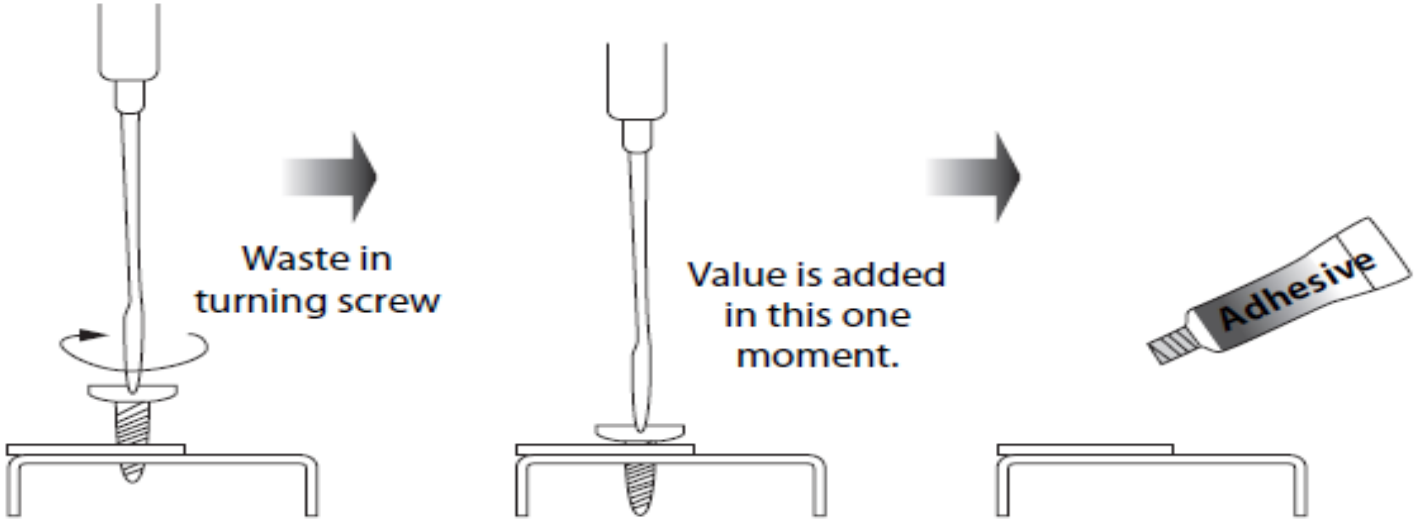
Processing

Solution: Analyze steps; identify non-value added ones; try to eliminate them



Fastening Operations

FUNCTION:
Fastening two workpieces so that they will not become separated



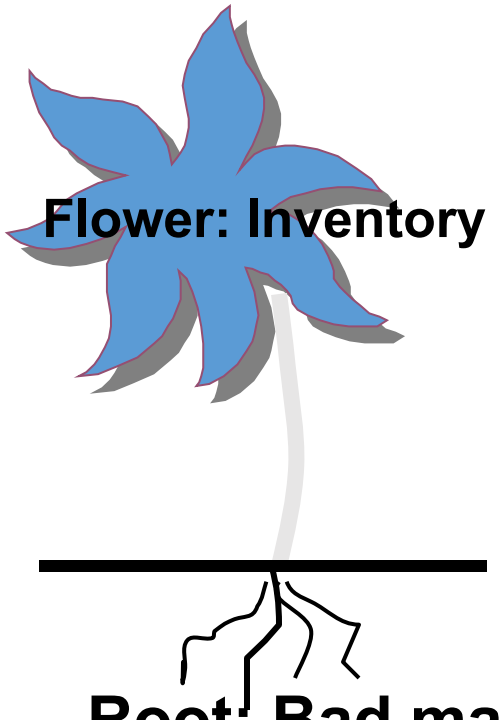
Adds no value

Only the last turn of the screw serves the fastening function.

Applying adhesive serves the same function and adds the same amount of value at lower cost.

Inventory

Inventory (the “Flower of all Evil”)



Motion (non-work)

Motion (non-work)

Solutions

- Improve facility layout
- Improve process and job design
- Clean up and organize workplace

Defects

Defects

Solutions

- Implement a system to *preclude* defects (pokayoke)
- Implement system to *immediately* identify and rectify defects (source inspection)

Examples of Waste...

MANUFACTURING

- Transportation
- Motion
- Defects
- Processing
- Waiting
- Inventory
- Overproduction

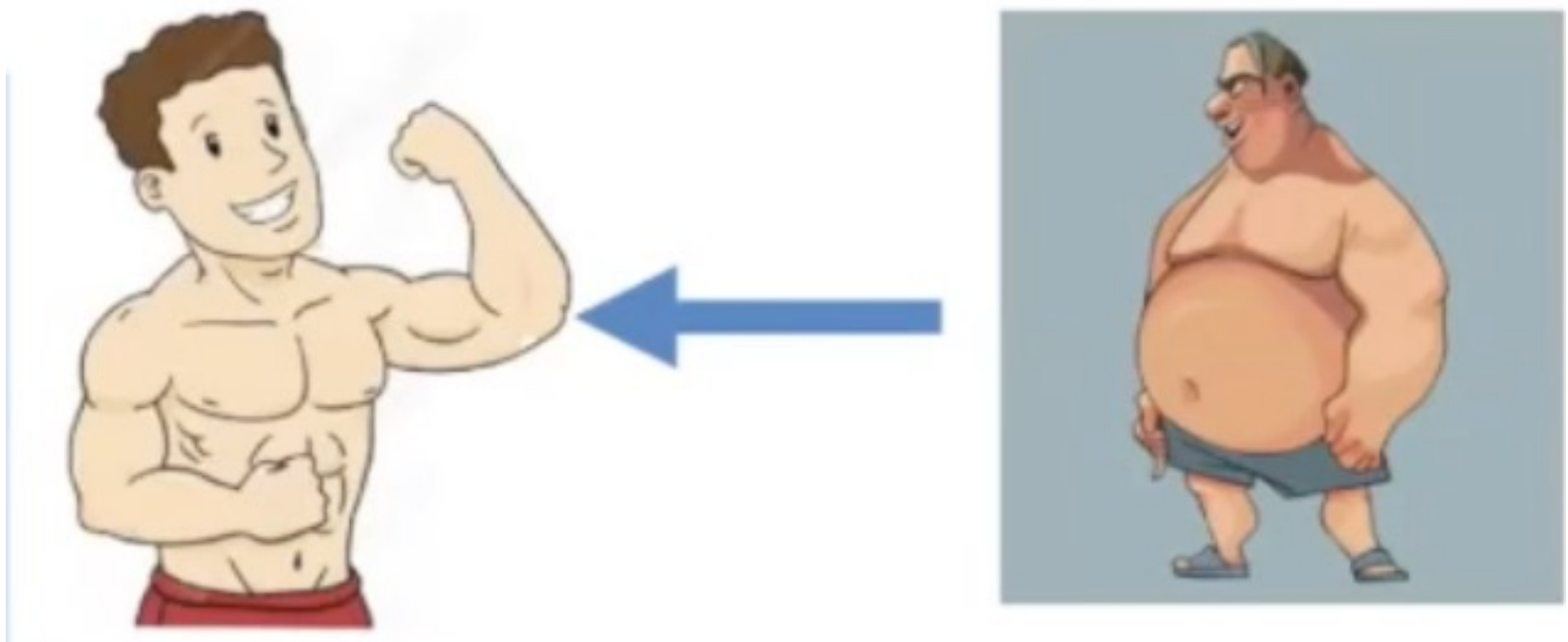
BUSINESS PROCESSES

- Transportation of documents
- Unnecessary motion
- Errors in documents
- Process steps and approvals
- Waiting for the next step
- Backlog of work
- Doing more/faster than reqd

Exercise

- Identify 8 Types of waste (TIMWOODS) in your Company and their reasons

https://www.youtube.com/watch?v=Kgevg68wSBA&ab_channel=ParasShenmare



Characteristics of Lean Systems

There are a number of characteristics that are commonly found in lean systems.

- **Waste Reduction-** A hallmark of lean systems.
- **Continuous improvement-** Another hallmark: never ending efforts to improve.
- **Use of teams-** Cross-functional teams, especially for process improvement.
- **Work-Cells-** Along with cellular layouts allow for better communication and use of people.
- **Visual controls-** Simple signals that enable efficient flow and quick assessment of operations.
- **High Quality-** In process and in output.
- **Minimal inventory-** Excess inventory is viewed as a waste.
- **Output only to match demand-** Throughout the entire systems; referred to a “demand pull”
- **Small lot sizes-** Enables verity for batch production.
- **Lean Culture-** The entire organization embraces lean concepts and strive to achieve them

Benefits Of lean Systems

- **There are numerous benefits of lean systems**
- Reduce waste due to emphasis on waste reduction (Environmental Sustainability)
- Lower costs due to reduced waste and lower inventories.
- Increased quality motivated by customers' 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 eliminations of non-value-added processes.