Lean and Agile Production Systems

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CHAPTER ONE: Lean Systems

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Learning Goals (1 of 2)

4.1 Describe how lean systems can facilitate the continuous improvement of processes.

4.2 Identify the strategic supply chain and process characteristics of lean systems.

4.3 Explain the differences between one-worker, multiple machine (OWMM) and group technology (GT) approaches to lean system layouts.

Learning Goals (2 of 2)

4.4 Understand Kanban systems for creating a production schedule in a lean system.

4.5 Understand value stream mapping and its role in waste reduction.

4.6 Explain the implementation issues associated with the application of lean systems.

What is a Lean System?

- **Lean Systems**
  - Operations systems that maximize the value added by each of a company's activities by removing waste and delays from them.

Continuous Improvement Using a Lean Systems Approach (1 of 5)

- **Just-in-time (JIT) system**
  - A key foundation of a lean system, and represents a collection of practices that eliminate waste, or *muda*, by cutting excess capacity or inventory and removing non-value-added activities.

Continuous Improvement Using a Lean Systems Approach (2 of 5)

Table 4.1 The Eight Types of Waste or Muda

Waste	**Definition**
1. Overproduction	Manufacturing an item before it is needed, making it difficult to detect defects and creating excessive lead times and inventory.
2. Inappropriate Processing	Using expensive high-precision equipment when simpler machines would suffice. It leads to overutilization of expensive capital assets. Investment in smaller flexible equipment, immaculately maintained older machines, and combining process steps where appropriate reduce the waste associated with inappropriate processing.
3. Waiting	Unbalanced workstations make operators lose time, because if a process step takes longer than the next, then the operators will either stand idly waiting, or they will be performing their tasks at a speed that makes it appear that they have work to complete. Operators can also be waiting when a previous process step breaks down, has quality issues, lacks certain parts or information, or has a long changeover.
4. Transportation	Excessive movement and material handling of product between processes, which can cause damage and deterioration of product quality without adding any significant customer value.

Continuous Improvement Using a Lean Systems Approach (3 of 5)

Table 4.1 [continued]

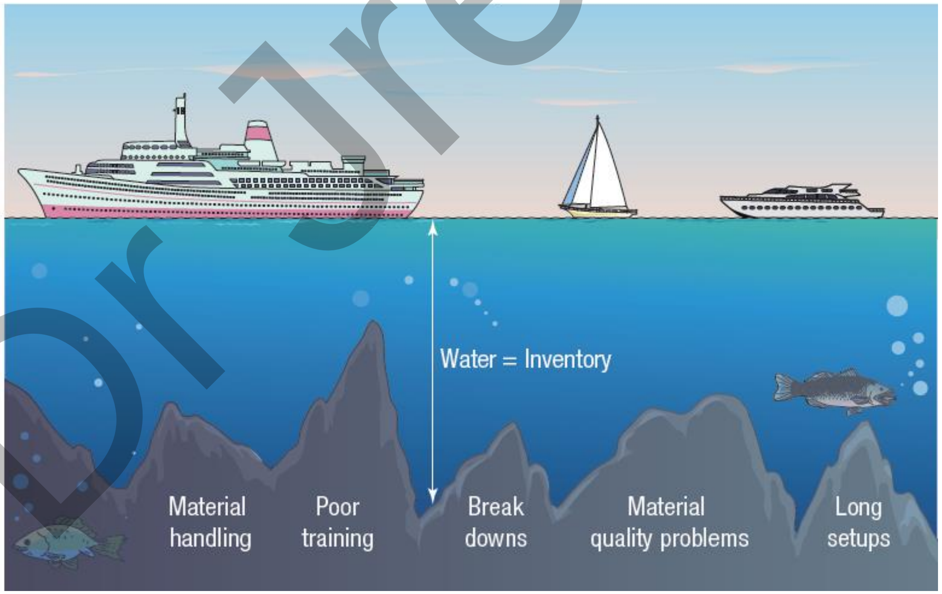
Waste	Definition
5. Motion	Unnecessary effort related to the ergonomics of bending, stretching, reaching, lifting, and walking. Jobs with excessive motion should be redesigned.
6. Inventory	Excess inventory hides problems on the shop floor, consumes space, increases lead times, and inhibits communication. Work-in-process inventory is a direct result of overproduction and waiting.
7. Defects	Quality defects result in rework and scrap and add wasteful costs to the system in the form of lost capacity, rescheduling effort, increased inspection, and loss of customer goodwill.
8. Underutilization of Employees	Failure of the firm to learn from and capitalize on its employees' knowledge and creativity impedes long-term efforts to eliminate waste.

Continuous Improvement Using a Lean Systems Approach (4 of 5)

Figure 4.1 Continuous Improvement with Lean Systems

The role of inventory in Traditional and JIT systems: The water and the rocks metaphor

Traditional systems use inventory (water) to buffer the process from problems (rocks) that cause disruption.

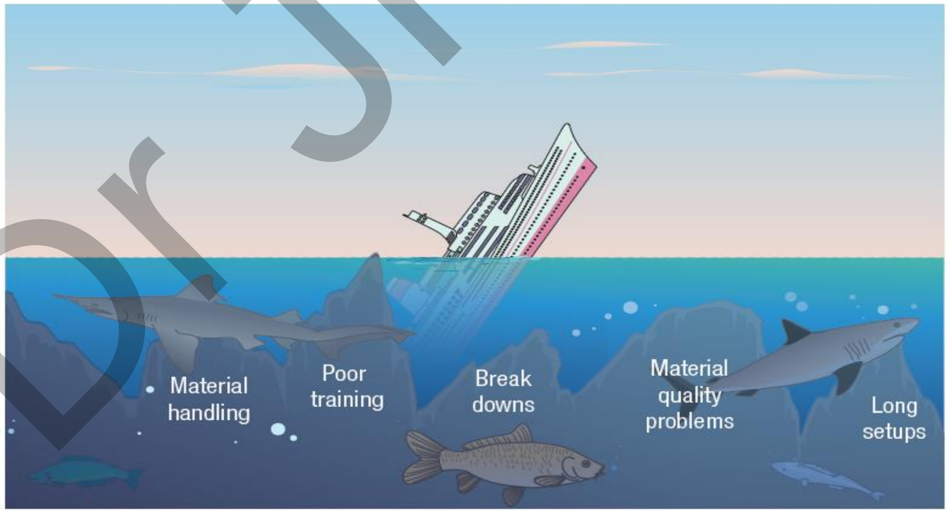


Continuous Improvement Using a Lean Systems Approach (5 of 5)

Figure 4.1 Continuous Improvement with Lean Systems

The role of inventory in Traditional and JIT systems: The water and the rocks metaphor

JIT systems view inventory as waste and work to lower inventory levels to expose and correct the problems (rocks) that cause disruption. However, the problems that arise must be corrected quickly. Otherwise, without decoupling inventory, the process will flounder.



Supply Chain Considerations in Lean Systems

- **Close Supplier Ties**
- **Small Lot Sizes**
  - Lot: a quantity of items that are processed together
  - Single-digit setup: the goal of having a setup time of less than 10 minutes

Process Considerations in Lean Systems (1 of 4)

- **Pull Method of Workflow (Lean)**
  - A method in which customer demand activates the production of the service or item.
- **Push Method of Workflow (Not Lean)**
  - A method in which production of the item begins in advance of customer needs.

Process Considerations in Lean Systems (2 of 4)

- **Quality at the Source**
  - Jidoka
    - Automatically stopping the process when something is wrong and then fixing the problems on the line itself as they occur.
  - Poka-Yoke
    - Mistake-proofing methods aimed at designing fail-safe systems that minimize human error.

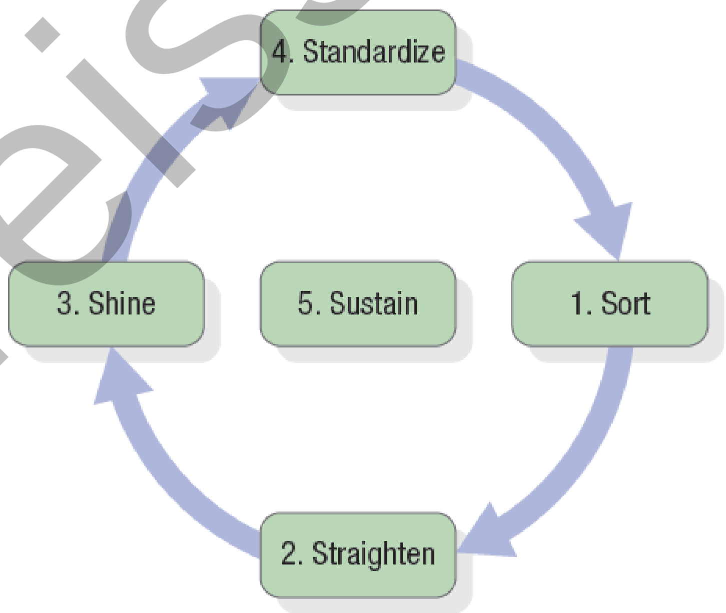
Process Considerations in Lean Systems (3 of 4)

- **Uniform Workstation Loads**
  - Takt time
  - Heijunka
  - Mixed-model assembly
- **Standardized Components and Work Methods**

Process Considerations in Lean Systems (4 of 4)

- Flexible Workforce
- Automation
- Five S (5S) Practices
- Total Productive Maintenance

Figure 4.2 5S Practices



Five S (5S) Practices

Table 4.2 5S Defined

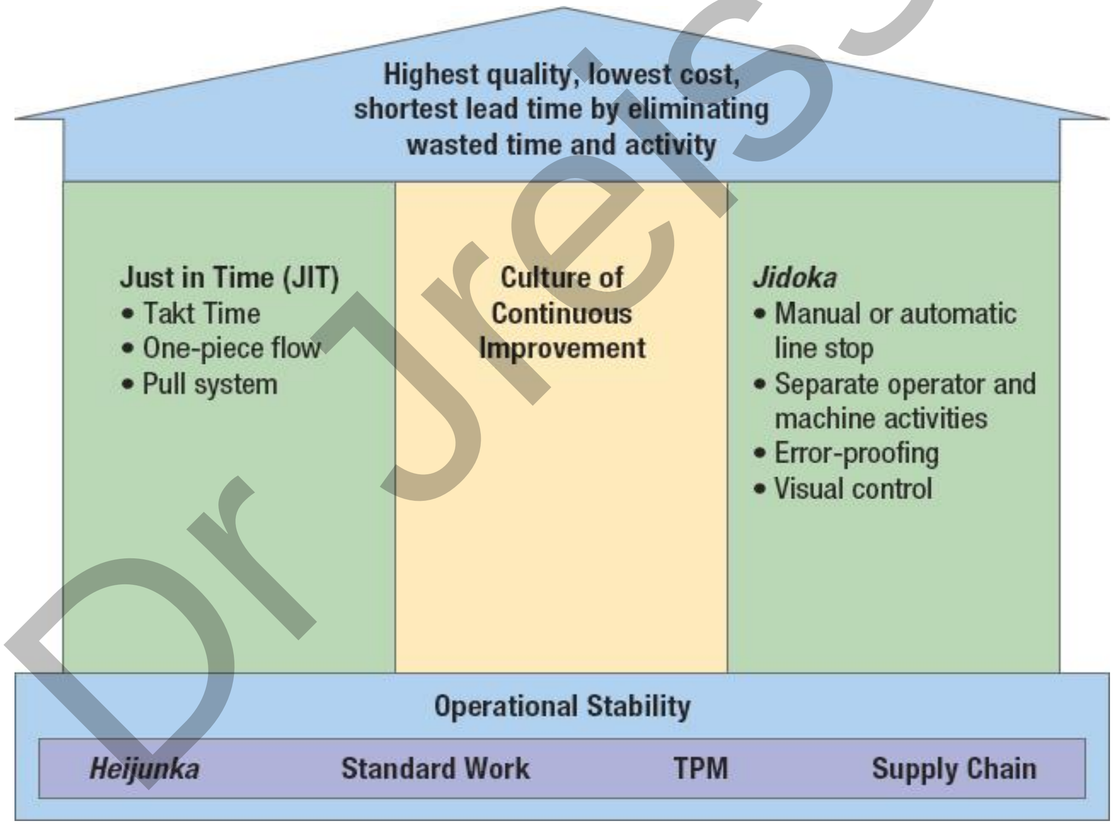
5S Term	Definition
1. Sort	Separate needed items from unneeded items (including tools, parts, materials, and paperwork), and discard the unneeded.
2. Straighten	Neatly arrange what is left, with a place for everything and everything in its place. Organize the work area so that it is easy to find what is needed.
3. Shine	Clean and wash the work area and make it shine.
4. Standardize	Establish schedules and methods of performing the cleaning and sorting. Formalize the cleanliness that results from regularly doing the first three S practices so that perpetual cleanliness and a state of readiness are maintained.
5. Sustain	Create discipline to perform the first four S practices, whereby everyone understands, obeys, and practices the rules when in the plant. Implement mechanisms to sustain the gains by involving people and recognizing them through a performance measurement system.

Toyota Production System (1 of 2)

- All work must be completely specified as to content, sequence, timing, and outcome.
- All customer-supplier connections should be direct and unambiguous.
- All pathways should be simple and direct.
- All improvements should be made under the guidance of a teacher using the scientific method.

Toyota Production System (2 of 2)

Figure 4.3 House of Toyota

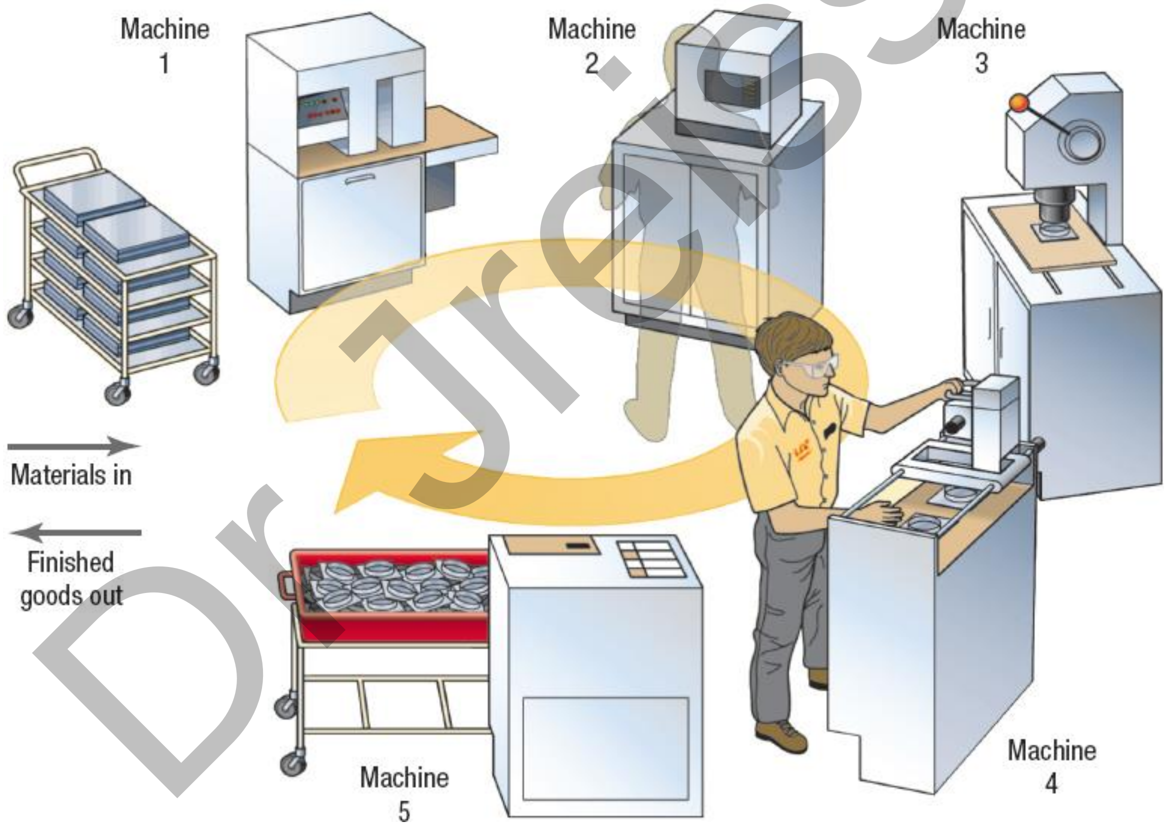


Designing Lean System Layouts

- **One-Worker, Multiple-Machines (OWMM) Cell**
  - A one-person cell in which a worker operates several different machines simultaneously to achieve a line flow.
- **Group Technology (GT)**
  - An option for achieving line-flow layouts with low volume processes
  - Creates cells not limited to just one worker
  - Has a unique way of selecting work to be done by the cell

One-Worker, Multiple Machines

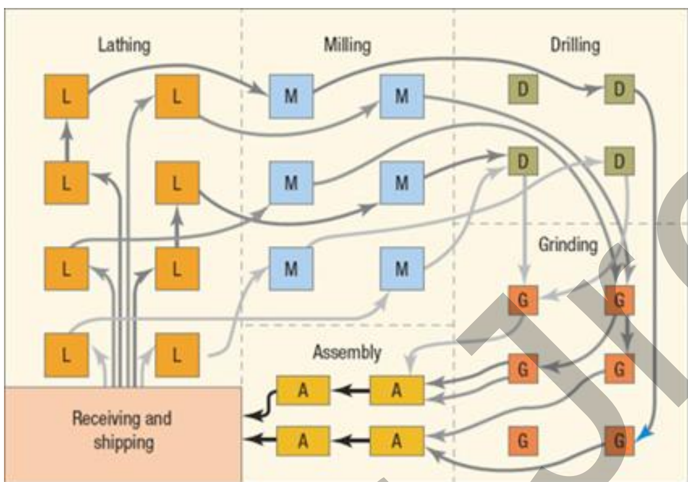
Figure 4.4 One-Worker, Multiple-Machines (OWMM) Cell



Group Technology

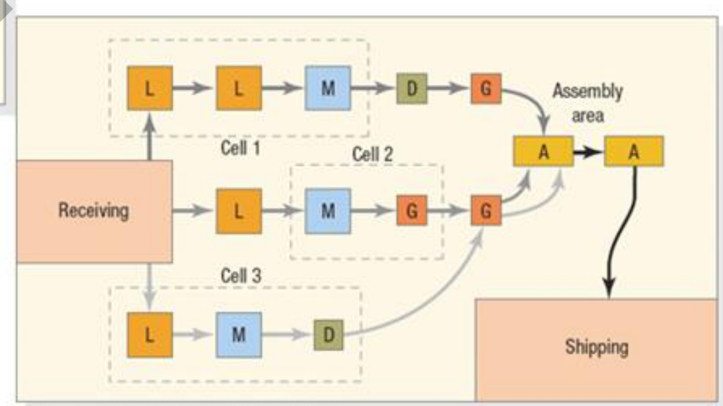
Figure 4.5 Process Flows Before and After the Use of GT Cells

Jumbled Flows
without GT



(a) Jumbled flows in a job shop without GT cells

Lines Flows with 3
GT cells



(b) Line flows in a job shop with three GT cells

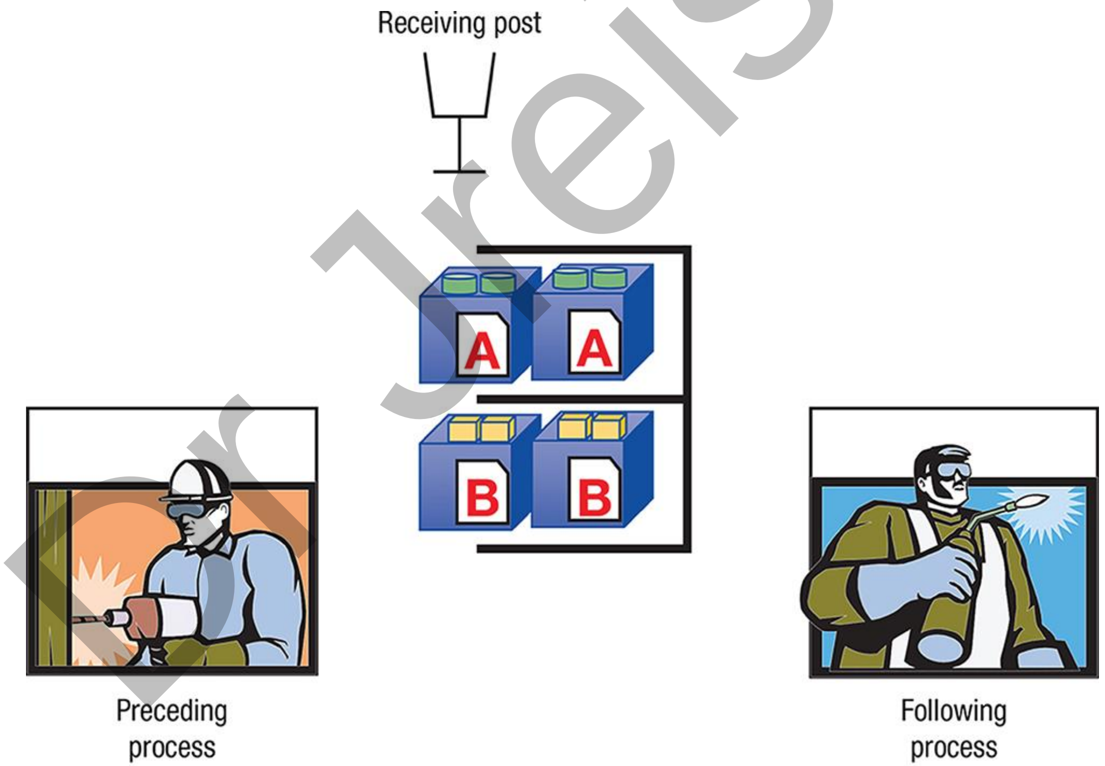
What is a Kanban?

- **Kanban**
  - A Japanese word meaning “card” or “visible record” that refers to cards used to control the flow of production through a factory

The Kanban System (1 of 5)

Figure 4.6 Kanban System Illustration

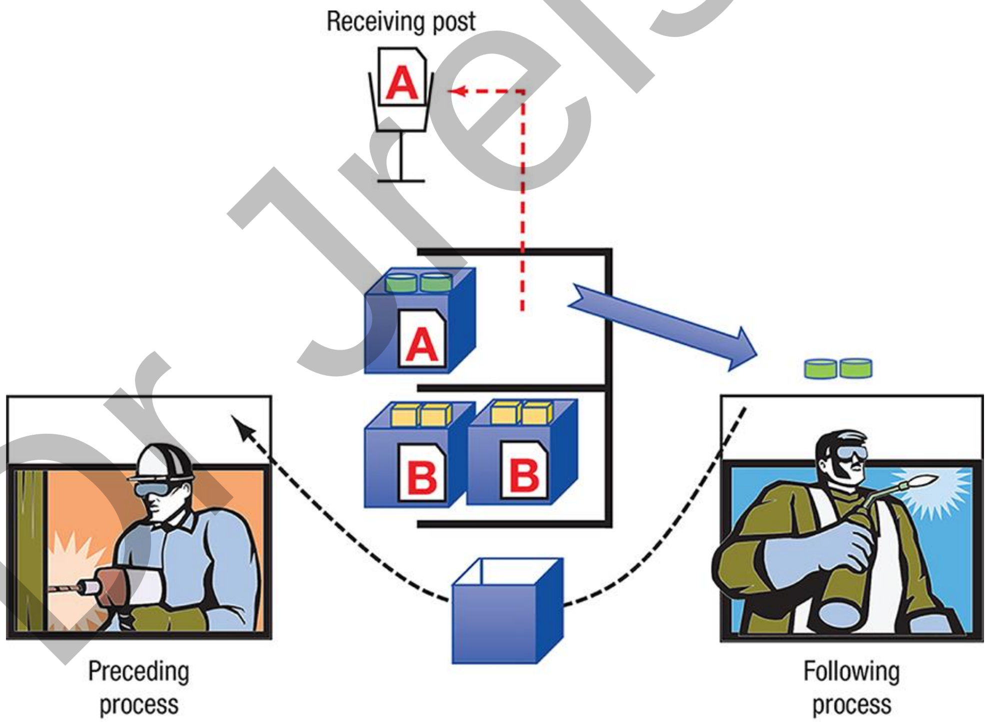
(a) Steady state starting condition



The Kanban System (2 of 5)

Figure 4.6 Kanban System Illustration

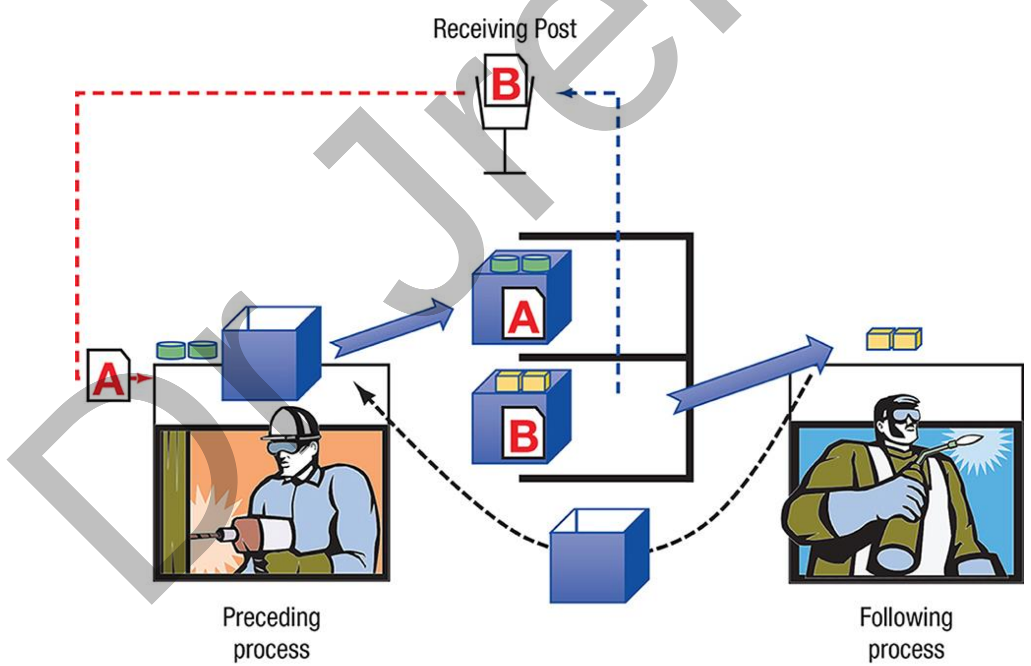
(b) Withdrawal of Part A by the following process and return of empty box to the preceding process to be filled up



The Kanban System (3 of 5)

Figure 4.6 Kanban System Illustration

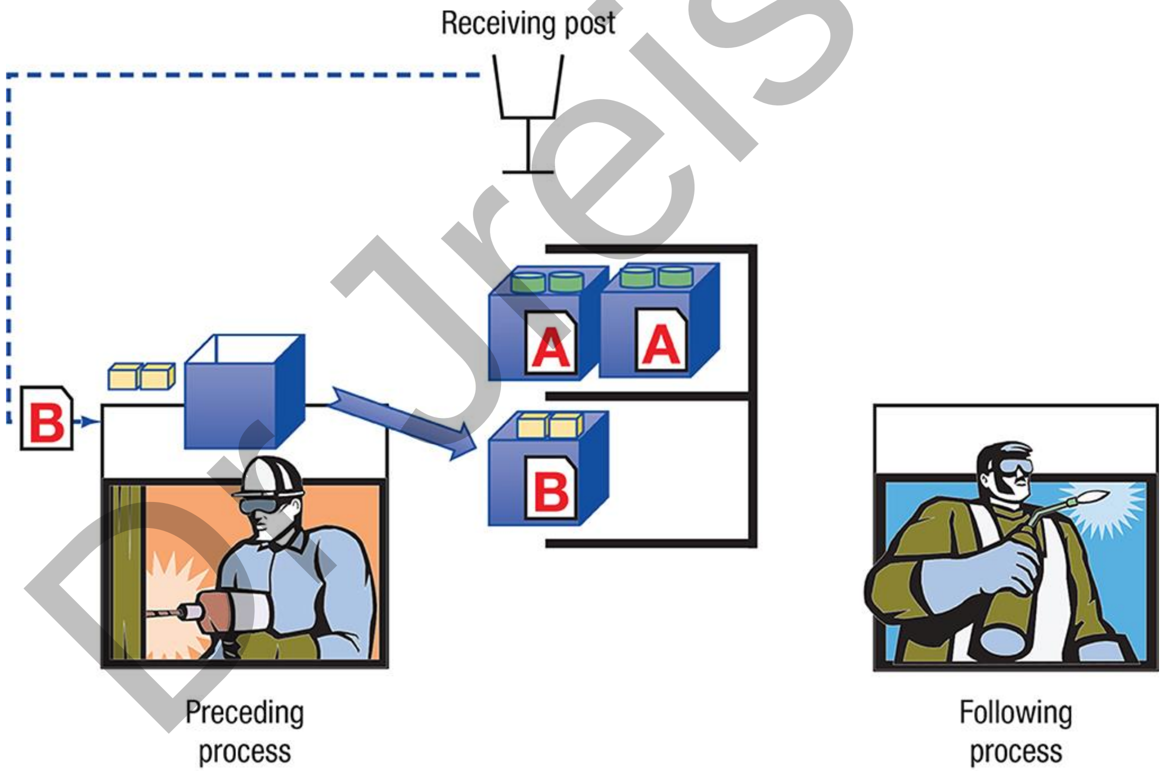
(c) Production of Part A at the preceding process. Withdrawal of Part B by the following process and return of empty box to the preceding process to be filled up



The Kanban System (4 of 5)

Figure 4.6 Kanban System Illustration

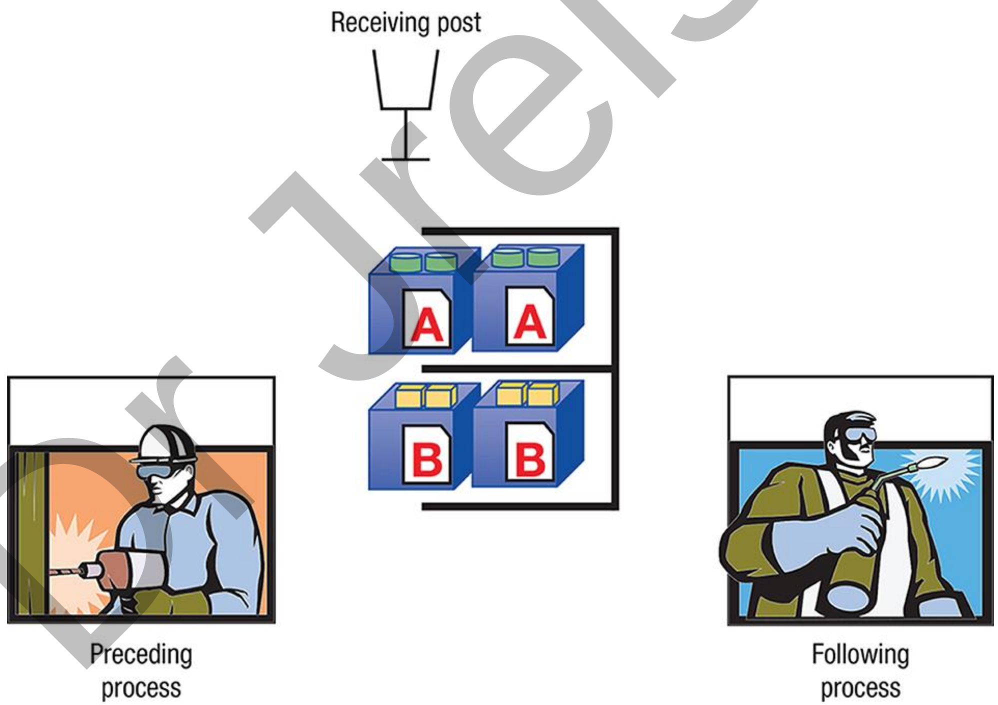
(d) Production of Part B at the preceding process



The Kanban System (5 of 5)

Figure 4.6 Kanban System Illustration

(e) Back to steady state again, waiting for production to start at the following process



General Operating Rules (1 of 2)

1. A full container must always have a card.
2. The preceding process will never produce parts without a card.
3. The following process must post the card at the receiving post before beginning consumption of the parts inside the containers.

General Operating Rules (2 of 2)

4. The containers should always contain the same number of good parts. The use of nonstandard containers or irregularly filled containers disrupts the production flow of the assembly line.
5. Only nondefective parts should be put into inventory with the card to make the best use of materials and worker's time. This rule reinforces the notion of building quality at the source, which is an important characteristic of lean systems, and guarantees that the following process will have enough inventory.

Determining the Number of Containers (1 of 2)

- **Two determinations**
  - Number of units to be held by each container
  - Number of containers
- **Little's Law**
  - Average work-in-process inventory equals the average demand rate multiplied by the average time a unit spends in the manufacturing process

Determining the Number of Containers (2 of 2)

Work in Process (WIP) = (average demand rate) × (average time a container spends in the manufacturing process) + safety stock

WIP = kc

$$kc = \bar{d}(\bar{\omega} + \bar{p})(1 + \alpha)$$

$$k = \frac{\bar{d}(\bar{\omega} + \bar{p})(1 + \alpha)}{c}$$

Where

k = number of containers

$\bar{d}$ = expected daily demand for the part

$\bar{\omega}$ = average waiting time

$\bar{p}$ = average processing time

c = number of units in each container

α = policy variable

Example 1 (1 of 2)

- The Westerville Auto Parts Company produces rocker-arm assemblies
- A container of parts spends 0.02 day in processing and 0.08 day in materials handling and waiting
- Daily demand for the part is 2,000 units
- Safety stock equivalent of 10 percent of inventory

a. If each container contains 22 parts, how many containers should be authorized?

b. Suppose that a proposal to revise the plant layout would cut materials handling and waiting time per container to 0.06 day. How many containers would be needed?

Example 1 (2 of 2)

if $\bar{d} = 2{,}000$

$\bar{p} = .02$ day

$\alpha = 0.10$

$\bar{\omega} = 0.08$ day

$c = 22$ units

$$k = \frac{2{,}000(0.08 + 0.02)(1.10)}{22}$$

$$= \frac{220}{22} = 10 \text{ containers}$$

b. Figure 4.7 from OM Explorer shows that with reduced waiting time, the number of containers drops to 8.

Figure 4.7 OM Explorer Solver for Number of Containers

Solver-Number of Containers

Enter data in yellow-shaded area.

Daily Expected Demand	2000
Quantity in Standard Container	22
Container Waiting Time (days)	0.06
Processing Time (days)	0.02
Policy Variable	10%
Containers Required	**8**

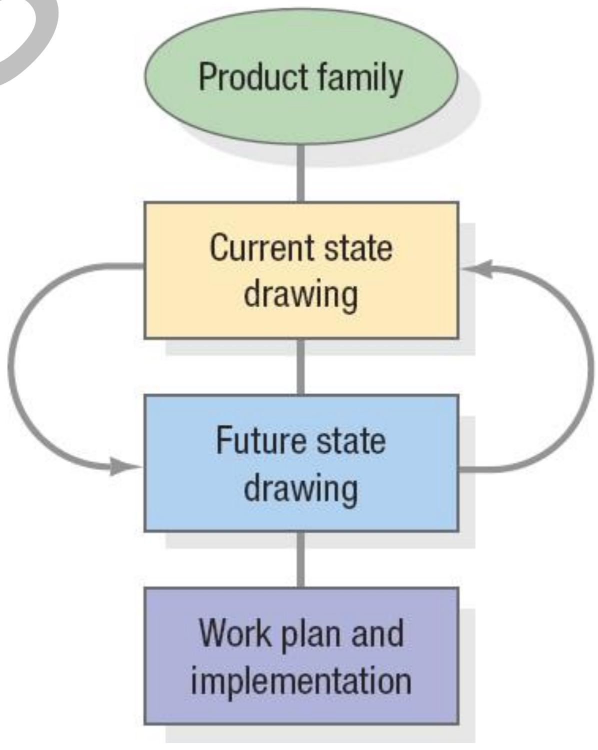
Other Kanban Signals

- **Container System**
  - Using the container itself as a signal device.
  - Works well with containers specifically designed for parts.
- **Containerless System**
  - Can use workbench areas to put completed units on painted squares.
  - Examples: a painted square on a workbench = one unit.

What is a Value Stream Mapping?

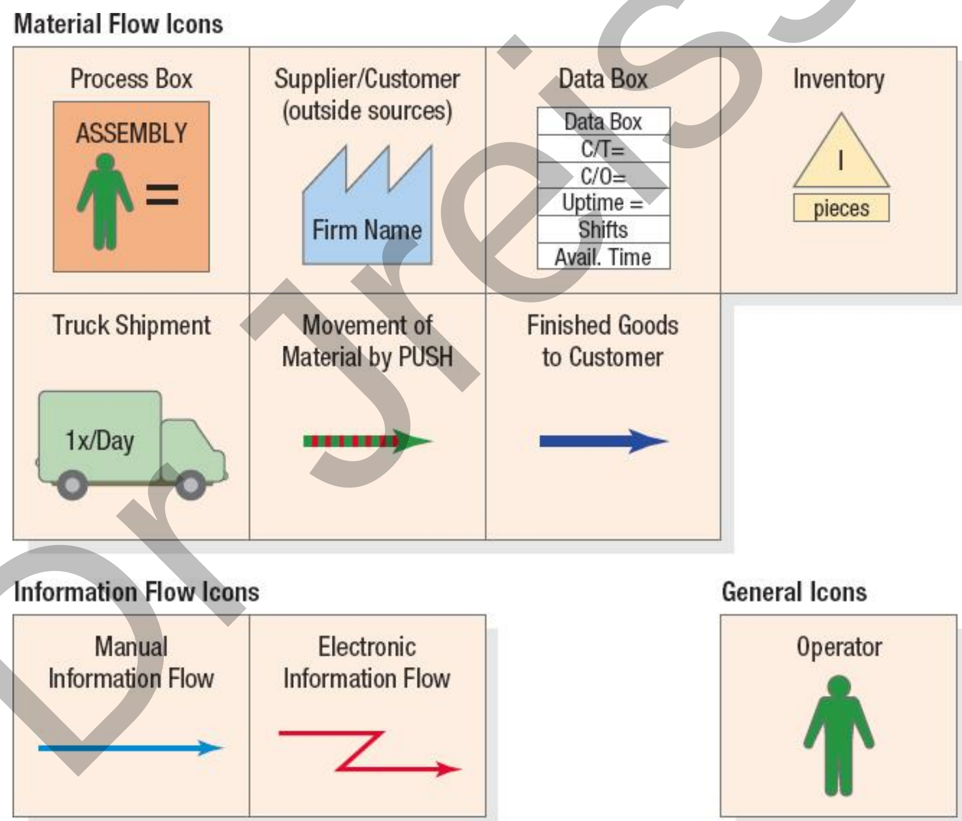
- **Value Stream Mapping**
  – A qualitative lean tool for eliminating waste, or *muda,* that involves a current state drawing, a future state drawing, and an implementation plan

Figure 4.8 Value Stream Mapping Steps



VSM Icons

Figure 4.9 Selected Set of Value Stream Mapping Icons Used for Mapping Current State



VSM Metrics

- **Takt Time =** $\frac{\text{Daily Availability}}{\text{Daily Demand}}$
- **Cycle Time**
- **Setup Time**
- **Per Unit Processing Time**
  - Cycle Time + Setup Time
- **Capacity =** $\frac{\text{Availability}}{\text{Time at Bottleneck}}$

Example 2 (1 of 7)

- Jensen Bearings Inc. makes two types of retainers that are packaged and shipped in returnable trays with 40 retainers in each tray. The operations data is on the following slides.
  a. Create a VSM for Jensen Bearings
  b. What is the takt time for this value stream?
  c. What is the production lead time at each process in the value stream?
  d. What is the total processing time of this value stream?
  e. What is the capacity of this value stream?

Example 2 (2 of 7)

Table 4.3 Operations Data for a Family of Retainers At Jensen Bearings, Inc.

Overall Process Attributes	**Average demand: 3,200/week (1,000 "L"; 2,200 "S")** **Batch size: 40** **Number of shifts per day: 1** **Availability: 8 hours per shift with two 30-minute lunch breaks**
Process Step 1	**Press** Cycle time = 12 seconds Setup time = 10 min Uptime = 100% Operators = 1 WIP = 5 days of sheets (Before Press)
Process Step 2	**Pierce & Form** Cycle time = 34 seconds Setup time = 3 minutes Uptime = 100% Operators = 1 WIP = 1,000 "L," 1,250 "S" (Before Pierce & Form)
Process Step 3	**Finish Grind** Cycle time = 35 seconds Setup time = 0 minutes Uptime = 100% Operators = 1 WIP = 1,050 "L," 2,300 "S" (Before Finish Grind)
Process Step 4	**Shipping** WIP = 500 "L," 975 "S" (After Finish Grind)

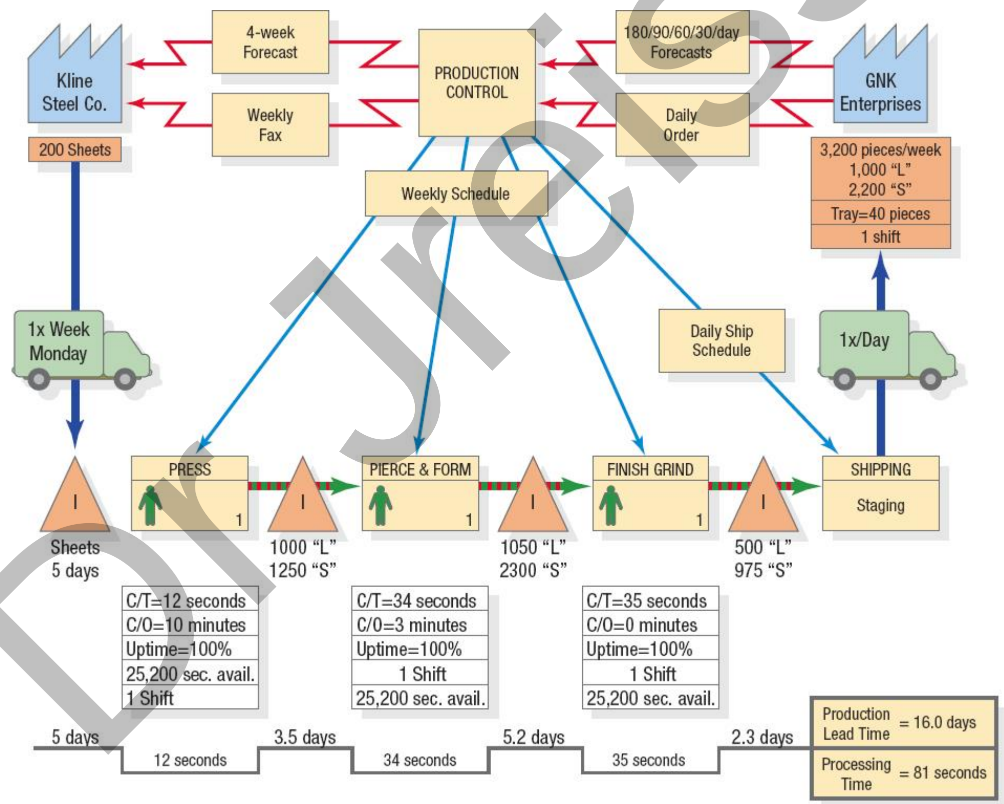
Example 2 (3 of 7)

Table 4.3 [continued]

Overall Process Attributes	**Average demand: 3,200/week (1,000 “L”; 2,200 “S”)** **Batch size: 40** **Number of shifts per day: 1** **Availability: 8 hours per shift with two 30-minute lunch breaks**
Customer Shipments	One shipment of 3,200 units each week in trays of 40 pieces
Information Flow	All communications from customer are electronic: 180/90/60/30/day Forecasts Daily Order All communications to supplier are electronic 4-Week Forecast Weekly Fax There is a weekly schedule manually delivered to Press, Pierce & Form, and Finish Grind and a Daily Ship Schedule manually delivered to Shipping All material is pushed

Example 2 (4 of 7)

a. Figure 4.10 Current State Map for a Family of Retainers at Jensen Bearings Incorporated



Example 2 (5 of 7)

b. Daily Demand

[(1,000 + 2,200) pieces/week]/5 days = 640 pieces per day

Daily Availability

(7 hours/day) × (3,600 seconds per hour) = 25,200 seconds per day

Takt Time

$$= \frac{\text{Daily availability}}{\text{Daily Demand}} = \frac{25,200}{640} = \textbf{39.375 seconds per piece}$$

Example 2 (6 of 7)

c. Production Lead time = $\frac{\text{Inventory}}{\text{Daily Demand}}$

Raw Material Lead Time = 5 days

WIP between Press and Pierce and Form $= \frac{2,250}{640} = 3.5 \text{ days}$

WIP between Pierce and Form and Finish Grind $= \frac{3,350}{640} = 5.2 \text{ days}$

WIP between Finish Grind and Shipping $= \frac{1,475}{640} = 2.3 \text{ days}$

Total Production Lead Time $= (5 + 3.5 + 5.2 + 2.3) = 16 \text{ days}$

d. Total Processing Time = Sum of the Cycle Times (12 + 34 + 35) = 81 seconds

Example 2 (7 of 7)

e.

Capacity at Press	Capacity at Pierce & Form	Capacity at Finish Grind
Cycle time = 12 seconds	Cycle time = 34 seconds	Cycle time = 35 seconds
Setup Time = $\frac{(10 \text{ min} * 60 \text{ seconds per min})}{40 \text{ units per batch}}$ = **15.0 seconds**	Setup Time = $\frac{(3 \text{ minutes} * 60 \text{ seconds per minute})}{40 \text{ units per batch}}$ = **4.5 seconds**	Setup Time = $\frac{(0 \text{ minutes} * 60 \text{ seconds per minute})}{40 \text{ units per batch}}$ = **0.0 seconds**
Per Unit Processing Time = (12 + 15) **= 27 seconds**	Per Unit Processing Time = (34 + 4.5) **= 38.5 seconds**	Per Unit Processing Time = (35 + 0.0) **= 35.0 seconds**

Pierce and Form is the bottleneck

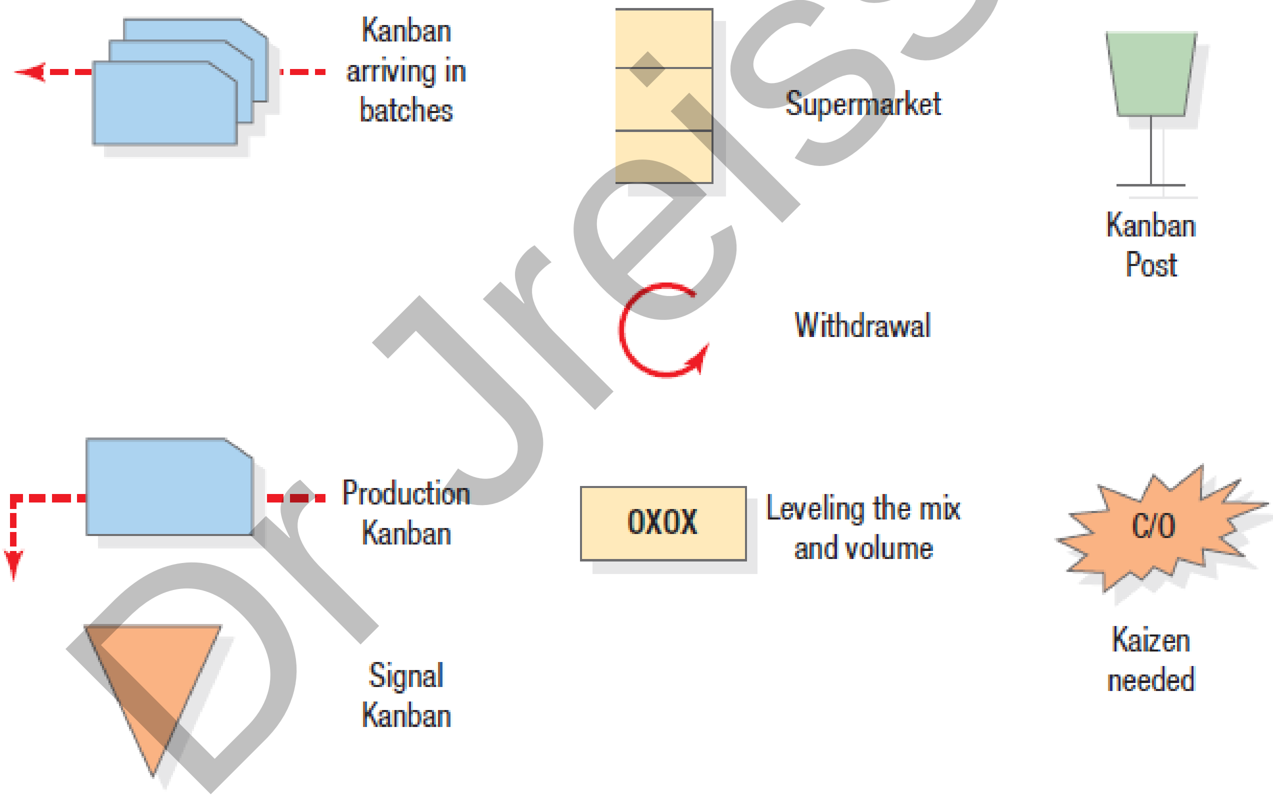
$$\text{Capacity} = \frac{25{,}200}{38.5} = \mathbf{654 \text{ units/day}}$$

Future State Map (1 of 3)

- **Future State Map**
  - A map that eliminates the sources of waste identified in the current state map.
- Steps in Creating a Future State Map
  1. Determine if the process steps are capable of producing according to the takt time
  2. Identify where in the value stream inventories can be totally eliminated by combining process steps
  3. Design pull systems to manage the remaining inventories
  4. Prepare and use an implementation plan to achieve the future state

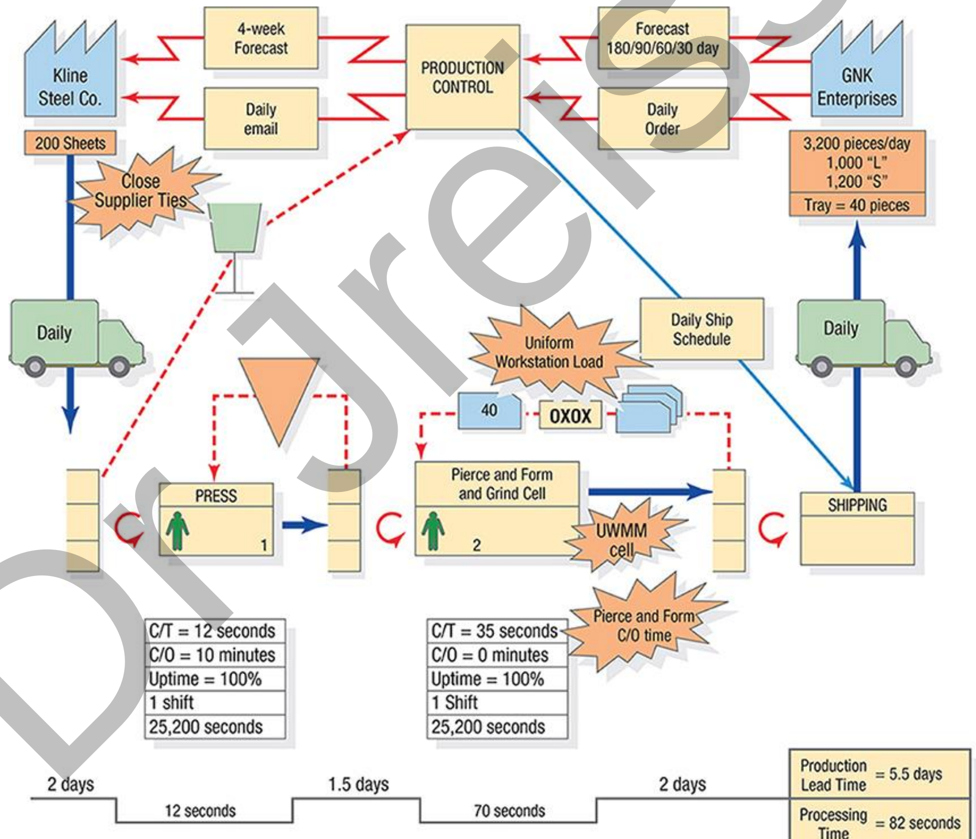
Future State Map (2 of 3)

Figure 4.11 Selected Set of Value Stream Icons Used for Mapping Future State



Future State Map (3 of 3)

Figure 4.12 Future State Map for a Family of Retainers at Jensen Bearings Incorporated



Organizational Considerations

- The Human Costs of Lean Systems
- Cooperation and Trust
- Reward Systems and Labor Classification

Process Considerations

- **To take advantage of lean practices, firms may have to consider process workflows. Examples include:**
  - Layout changes
  - Rearranging workstations
  - Changes in material movement and logistics
  - More frequent deliveries

Inventory and Scheduling

- **Inventory and Scheduling**
  - Schedule Stability
  - Setups
  - Purchasing and Logistics

Solved Problem 1 (1 of 3)

A company using a Kanban system has an inefficient machine group. For example, the daily demand for part L105A is 3,000 units. The average waiting time for a container of parts is 0.8 day. The processing time for a container of L105A is 0.2 day, and a container holds 270 units. Currently, 20 containers are used for this item.

a. What is the value of the policy variable, **α**?

b. What is the total planned inventory (work-in-process and finished goods) for item L105A?

c. Suppose that the policy variable, **α**, was 0. How many containers would be needed now? What is the effect of the policy variable in this example?

Solved Problem 1 (2 of 3)

a. We use the equation for the number of containers and then solve for **α**:

$$k = \frac{\bar{d}(\bar{\omega} + \bar{p})(1 + \alpha)}{c}$$

$$20 = \frac{3{,}000(0.8 + 0.2)(1 + \alpha)}{270}$$

$$(1 + \alpha) = \frac{20(270)}{3{,}000(0.8 + 0.2)} = 1.8$$

$$\alpha = 1.8 - 1 = \mathbf{0.8}$$

Solved Problem 1 (3 of 3)

b. With 20 containers in the system and each container holding 270 units, the total planned inventory is

$$20(270) = 5,400 \text{ units}$$

c. If α = 0

$$k = \frac{3,000(0.8 + 0.2)(1 + 0)}{270}$$

$$= 11.11, \text{ or } 12 \text{ containers}$$

Solved Problem 2 (1 of 7)

Metcalf, Inc makes brackets for two major automotive customers. The operations data is on the following slides.

a. Create a VSM for Metcalf Bearings

b. What is the takt time for this value stream?

c. What is the production lead time at each process in the value stream?

d. What is the total processing time of this value stream?

e. What is the capacity of this value stream?

Solved Problem 2 (2 of 7)

Table 4.4 Operations Data for Brackets At Metcalf, Inc.

Overall Process Attributes	**Average demand: 2700/day** **Batch size: 50** **Number of shifts per day: 2** **Availability: 8 hours per shift with a 30-minute lunch break**
Process Step 1	**Forming** Cycle time = 11 seconds Setup time = 3 minutes Up time = 100% Operators = 1 WIP = 4000 units (Before Forming)
Process Step 2	**Drilling** Cycle time = 10 seconds Setup time = 2 minutes Up time = 100% Operators = 1 WIP = 5,000 units (Before Drilling)
Process Step 3	**Grinding** Cycle time = 17 seconds Setup time = 0 minutes Up time = 100% Operators = 1 WIP = 2,000 units (Before Grinding)

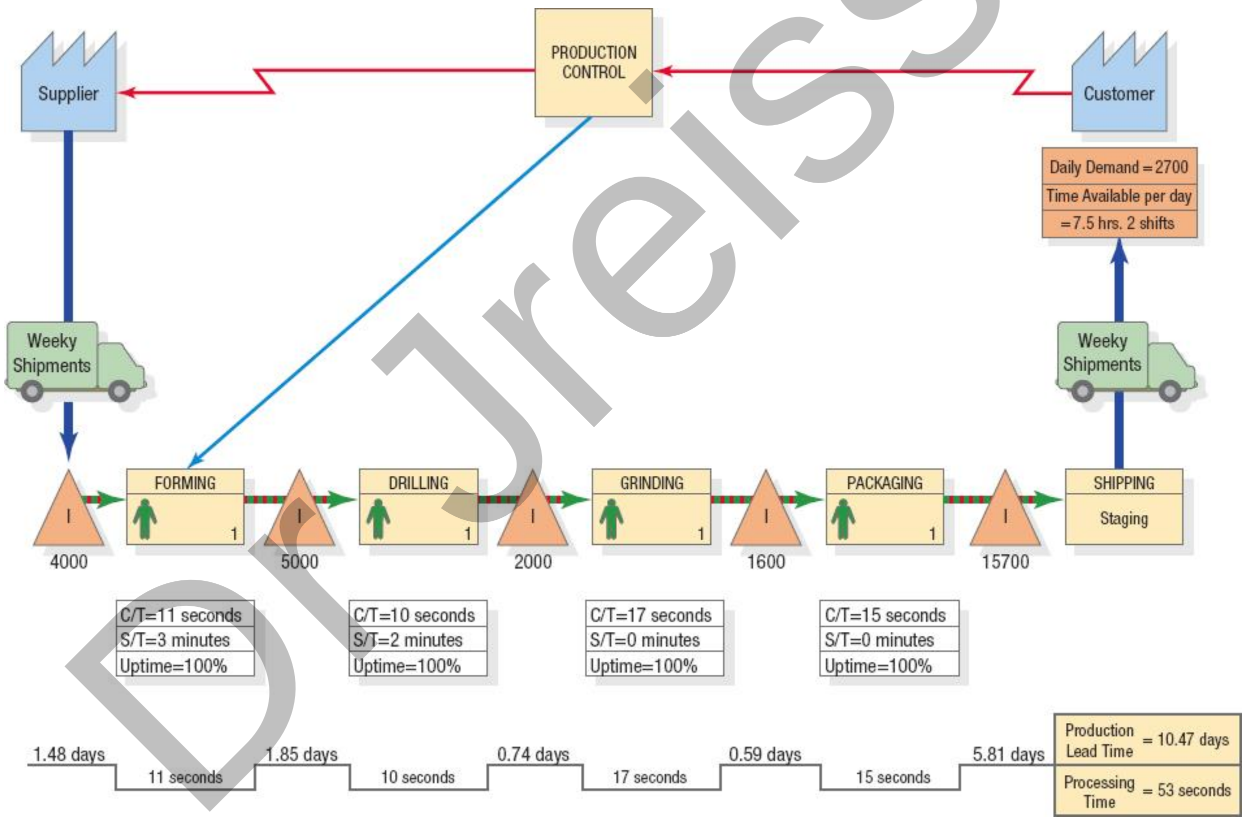
Solved Problem 2 (3 of 7)

Table 4.4 [continued]

Overall Process Attributes	**Average demand: 2700/day** **Batch size: 50** **Number of shifts per day: 2** **Availability: 8 hours per shift with a 30-minute lunch break**
Process Step 4	**Packaging** Cycle time = 15 seconds Setup time = 0 minutes Up time = 100% Operators = 1 WIP = 1,600 units (Before Packaging) WIP = 15,700 units (Before Shipping)
Customer Shipments	One shipment of 13,500 units each week
Information Flow	All communications with customer are electronic There is a weekly order release to Forming All material is pushed

Solved Problem 2 (4 of 7)

Figure 4.13 Current State Value Stream Map for Metcalf, Inc.



Solved Problem 2 (5 of 7)

b. Daily Demand

2,700 units per day

Daily Availability

$$(7.5 \text{ hours/day}) \times (3,600 \text{ seconds per hour}) \times (2 \text{ shifts/day})$$

$$= \mathbf{54,000 \text{ seconds per day}}$$

$$\text{Takt Time} = \frac{\text{Daily availability}}{\text{Daily Demand}} = \frac{54,000}{2,700} = \mathbf{20 \text{ seconds per unit}}$$

Solved Problem 2 (6 of 7)

c. Production Lead time = $\dfrac{\text{Inventory}}{\text{Daily Demand}}$

Raw Material Lead Time $= \dfrac{4{,}000}{2{,}700} = 1.48 \text{ days}$

WIP between Forming and Drilling $= \dfrac{5{,}000}{2{,}700} = 1.85 \text{ days}$

WIP between Drilling and Grinding $= \dfrac{2{,}000}{2{,}700} = .74 \text{ day}$

WIP between Grinding and Packaging $= \dfrac{1{,}600}{2{,}700} = .59 \text{ day}$

Finished Goods Lead Time before Shipping $= \dfrac{15{,}700}{2{,}700} = 5.81 \text{ days}$

Total Production Lead Time = (1.48 + 1.85 + .74 + .59 + 5.81) = 10.47 days

Solved Problem 2 (7 of 7)

d. Total Processing Time = Sum of the Cycle Times (11 + 10 + 17 + 15) = 53 seconds

Capacity at Forming	Capacity at Drilling	Capacity at Grinding	Capacity at Packaging
Cycle time = 11 seconds	Cycle time = 10 seconds	Cycle time = 17 seconds	Cycle time = 15 seconds
Setup Time = $\frac{(3 \text{ minutes} * 60 \text{ seconds per minute})}{50 \text{ units per batch}} = 3.6$ seconds	Setup Time = $\frac{(2 \text{ minutes} * 60 \text{ seconds per minute})}{50 \text{ units per batch}} = 2.4$ seconds	Setup Time = **zero Seconds**	Setup Time = **zero seconds**
Per Unit Processing Time = (11 + 3.6) = **14.6 seconds**	Per Unit Processing Time = (10 + 2.4) = **12.4 seconds**	Per Unit Processing Time = (17 + 0) = **17.0 seconds**	Per Unit Processing Time = (15 + 0) = **15.0 seconds**

Grinding is the bottleneck Capacity = $\frac{54{,}000}{17}$ = **3,176 units/day**

Lean Manufacturing Overview

- Definition
- Waste identification and reduction
- 5S
- Cellular Manufacturing
- JIT
- Design with Lean in mind
- Value Stream Mapping

Lean Manufacturing Definition

"A philosophy of production that emphasizes the minimization of the amount of all the resources (including time) used in the various activities of the enterprise. It involves identifying and eliminating non-value-adding activities in design, production, supply chain management, and dealing with the customers. . ."

– APICS

Lean Enterprise Definition

"An enterprise with a focus on waste elimination and the customer's needs in all parts of its operations, manufacturing, and administration. Emphasis is given to lean structures and processes, flexibility of response, and methods and techniques to continually seize new opportunities as they arise."

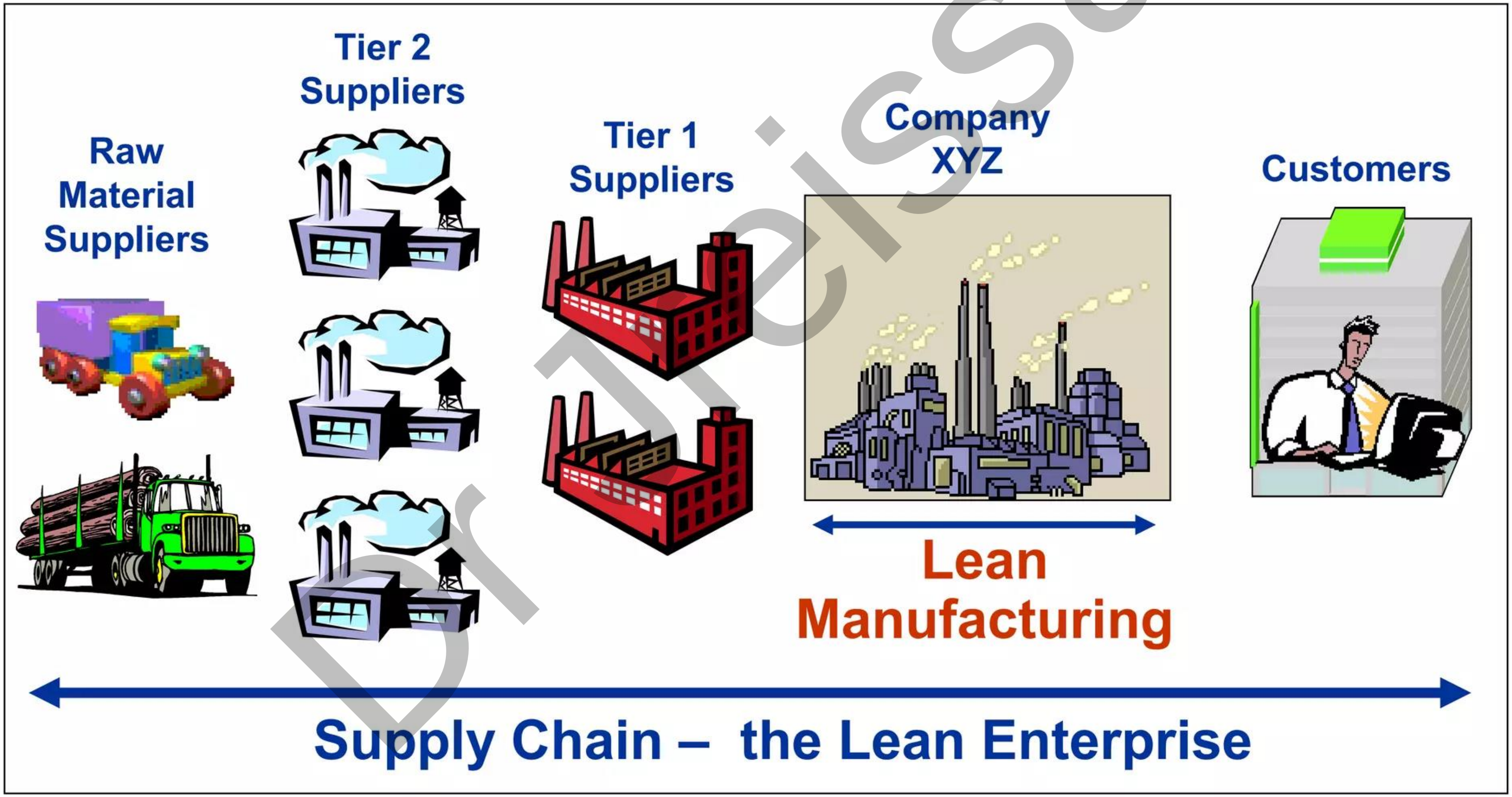
– APICS

Lean Thinking Principles

1. Accurately specify the value of the products or services (applies to both factory and office areas, not just to manufacturing).
2. Identify the value stream for each product or service and remove wasted actions (muda).
3. Make the product or service value flow without interruptions.
4. Let customers pull products or services from the producer.
5. Pursue perfection and continuously improve.

Lean Manufacturing, Supply Chain, and the Lean Enterprise

LEAN SIG



Lean Manufacturing Characteristics

- **Focus is on the improvement of resource utilization:**
  - Equipment setup time reduced
  - Scheduled machine maintenance
  - Orderly, clean workplace
  - Pull production being used
  - JIT inventory control
  - Factory layout in workcell arrangement by products
  - Active error elimination
  - Improved quality, etc.

Set big, hairy audacious goals (BHAG)

- 50% reduction in defects every year
- 100% on-time delivery
- Reduce order-to-ship time to less than a day
- Increase Inventory turns per year
- Reduce time-to-market by 75%
- Reduce costs (hours/widget)

The Importance of Waste Elimination

Lean deals with the elimination or reduction of many types of non value-added activities, often referred to as waste (Muda).

The driving force for waste elimination is improved value in the products and services customers buy.

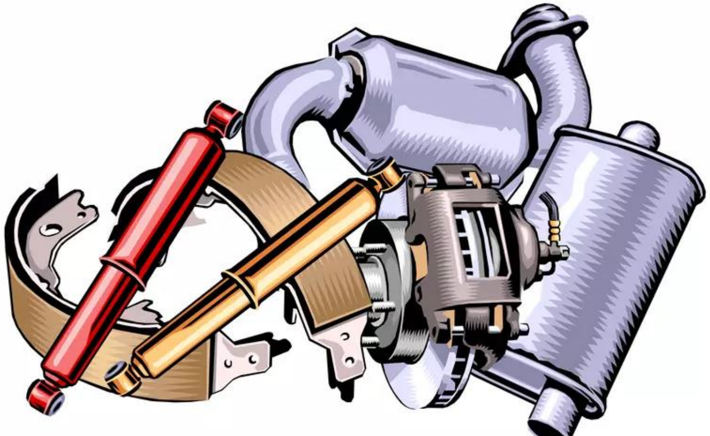
The Seven Popular Wastes from TPS

1. **D**efects
2. **O**verproduction
3. **T**ransportation
4. **W**aiting
5. **I**nventories
6. **M**otion
7. **P**rocessing

The Nature of Wastes

Defects

- Low material yields
- Excessive process variability



The Nature of Wastes

Overproduction

- Target and achievement unclear
- Excessive lead time and storage times

Transportation

- Widely spaced equipment
- Forklifts not available when needed

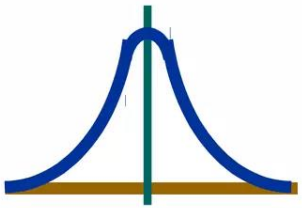
Waiting

- Operators waiting
- Operators slower than production line

The Nature of Wastes

Inventory

- Large safety stocks
- Variable procurement lead times



Motion

- Double handling
- Equipment widely spaced from each other

Inappropriate Processing

- Variability in operator's performance
- Processes not statistically capable

Correcting Wastes

Defects

- Develop the production process to prevent defects from being made and eliminate the need for inspection. At each process, produce no defects. Design processes to be failsafe to assure this. From a quality process comes a quality product—automatically.

Correcting Wastes

- **Overproduction**
  - Eliminate by reducing setup times, synchronizing quantities and timing between processes, compacting layouts, etc. Make only what is needed now.

- **Transportation**
  - Establish layouts and locations to make transport and handling unnecessary, if possible.

Correcting Wastes

Waiting

- Eliminate through synchronizing work flow as much as possible and balancing uneven loads with flexible workers and equipment.

Inventory

- Reduce by shortening setup times and lead times by synchronizing work flows and improving work skills, even by smoothing fluctuations in demand for the product. Reducing all the other wastes reduces the waste of stocks.

Correcting Wastes

Motion

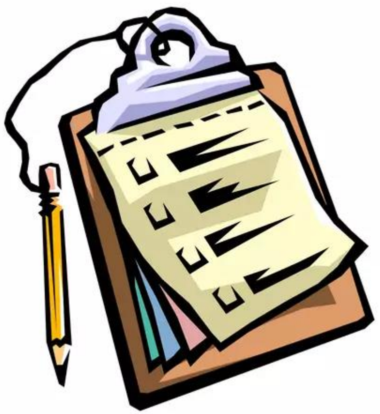
- Study motion for economy and consistency. Economy improves productivity, and consistency improves quality. First improve the motions, then mechanize or automate. Otherwise, there is a danger of automating waste.

Processing

- First questions to ask are why should this item be made at all, then why is each process necessary. Extend thinking beyond economy of scale or speed.

Seven Additional Wastes within Manufacturing

1. Wasted power and energy
2. Wasted human potential
3. Environmental pollution
4. Unnecessary overhead
5. Inappropriate design
6. Departmental culture
7. Inappropriate information



The 5 Ss

- To eliminate waste, you must first find it.
- Visual order makes waste evident and is a starting point for managing resources.
- Good housekeeping uses the Toyota Production System's 5 Ss as the method for improvement by exposing waste and poor utilization of resources.

The 5 Ss

LEAN SIG

	Japanese		American	American	CANDO
1.	Seiri:	Organization	Sort	Sifting	Cleanup
2.	Seiton:	Tidiness	Set in order	Sweeping	Arranging
3.	Seiso:	Purity	Shine	Sorting	Neatness
4.	Seiketsu:	Cleanliness	Standardize	Sanitizing	Discipline
5.	Shitsuke:	Discipline	Sustain	Sustaining	Ongoing Improvement

The 5S's with Safety

Sort: Classify tools, parts, instructions into necessary and unnecessary. Get rid of the later.

Set in Order: Make it visible and easy to use:
3 Es = easy to see, easy to get, and easy to return.

Shine: Conduct cleanup to identify abnormalities.

Standardize: Put a system in place to readily identify abnormal conditions.

Safety: Identify and eliminate dangerous and hazardous conditions.

Sustain: Make a habit of properly maintaining and following standard practices.

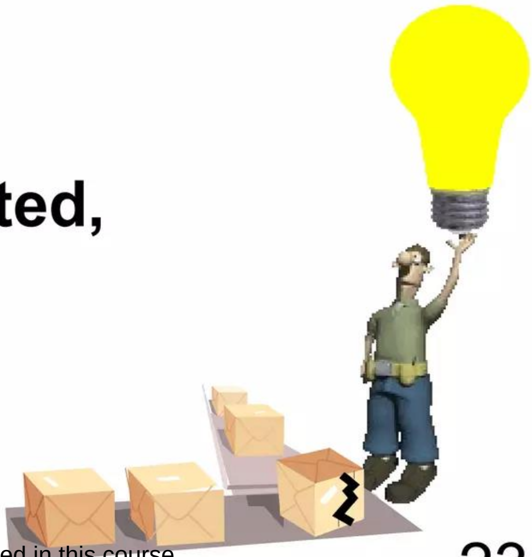
Shadow Boarding

Correct

Incorrect

Andon Warning Lights

- **Andon lights are visual tools that enable operators to signal the need for immediate assistance whenever production flow is affected.**
  - **When an abnormality is detected, a supervisor and support personnel rapidly respond.**



What Are Processes?

- A particular method of doing something, generally involving a number of steps, activities, or operations.
- Processes are found in manufacturing and service industries.
- Example:

Manufacturing	Grind	Turn	Mill	Drill
Office	Type contract	Obtain signature	Type envelope	Mail

What Are Value-Added Activities?

- Value-added activities are those that add value to products and services that customers are willing to pay for.
  - Improvements that change a product's or service's form, fit, or function.
- Other activities use resources but add no value.
  - Some non-value-added activities may be necessary if they cannot be eliminated based on current knowledge or technology. Eliminate long term.
  - Remaining non-value-added activities should be eliminated currently.

A Value-Added Step

- **A value-added step in a process is one that physically changes the work passing through the process or the work output produced to make it more valuable to the customer.**
- **A step requested by the customer that he or she is willing to pay for.**
- **A legally required mandate.**

Value- Versus Non-Value-Added

Value-Added Activities

- Entering order
- Ordering materials/supplies
- Preparing drawings
- Assembling
- Shipping to customers
- Processing customer deposits
- Examining patients
- Filing insurance claims
- Dispensing event tickets
- Fueling airplane

Non-Value-Added Activities

- Waiting/sorting
- Moving
- Kitting/staging
- Counting
- Inspecting
- Checking
- Recording
- Obtaining approvals
- Testing
- Reviewing
- Copying
- Filing
- Revising/reworking
- Tracking work

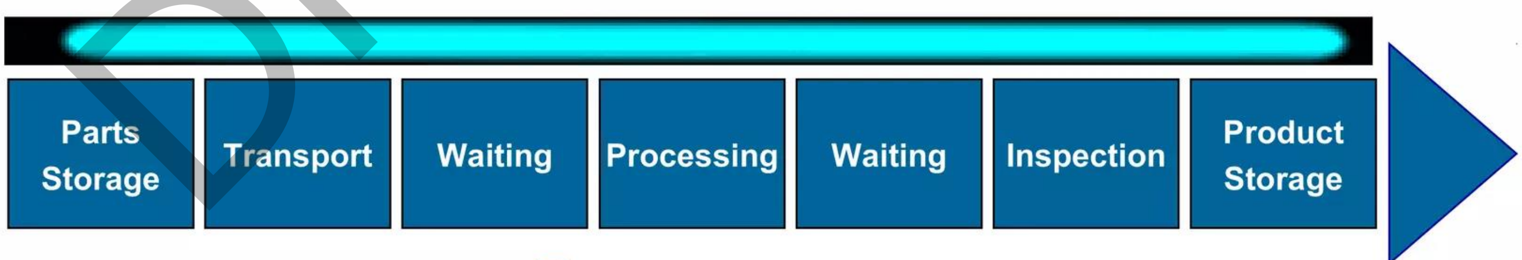
– **Charlene B. Adair and Bruce A. Murray,** ***Breakthrough Process Redesign***

Emphasis Is on Process Flow

- Five separate activities take place: storage, transport, waiting, processing, and inspection.

Manufacturing Cycle
(Queue, Setup, Run, Wait, and Move)

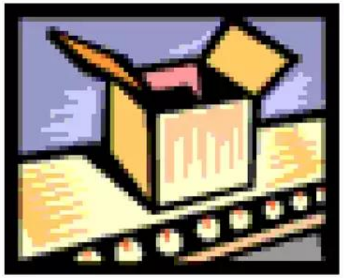
- Lean maximizes efficiency by analyzing and streamlining process flow before trying to improve discrete operations.



Processes

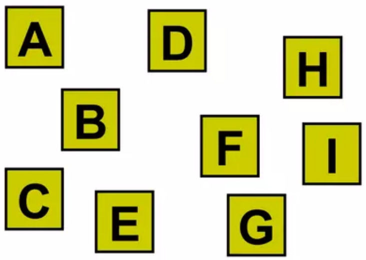
Continuous Flow

- In flow layouts, operations are sequential
  - Operators understand the total process.
  - Products move singularly.
  - Buffer stocks are not required because lines are balanced.
  - The flow path is predefined.
  - Equipment is right-sized.
  - Emphasis is on faster flows.



Production Systems

LEAN SIG



Functional Layout

Batch

Not a flow system

Consider converting to flow

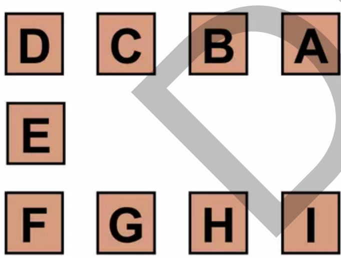
Production Line

Batch or flow

Load balancing important

Line balancing important

Mixed-model scheduling



Cellular

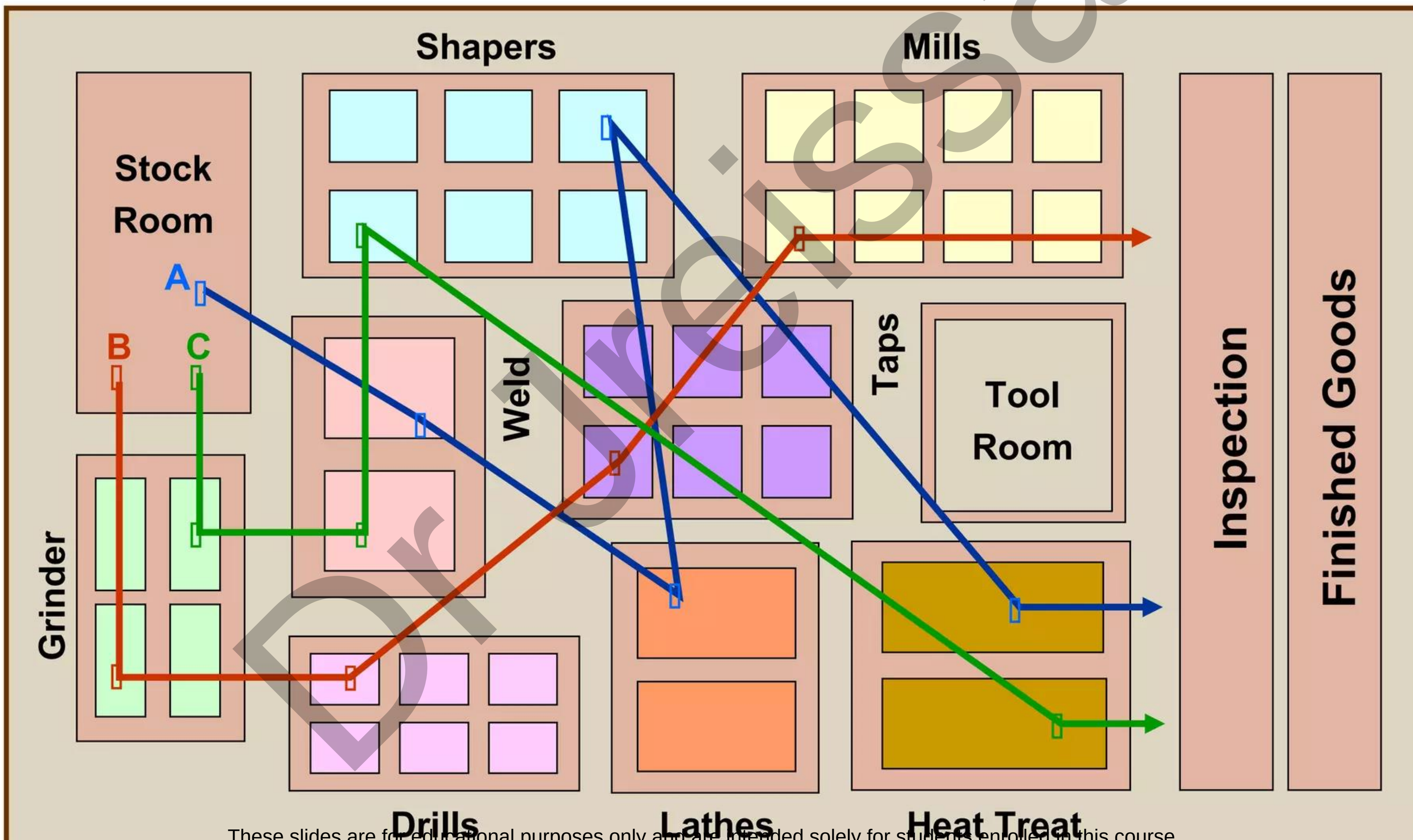
Flow - build in lots of one

Line balancing necessary

Can use takt time

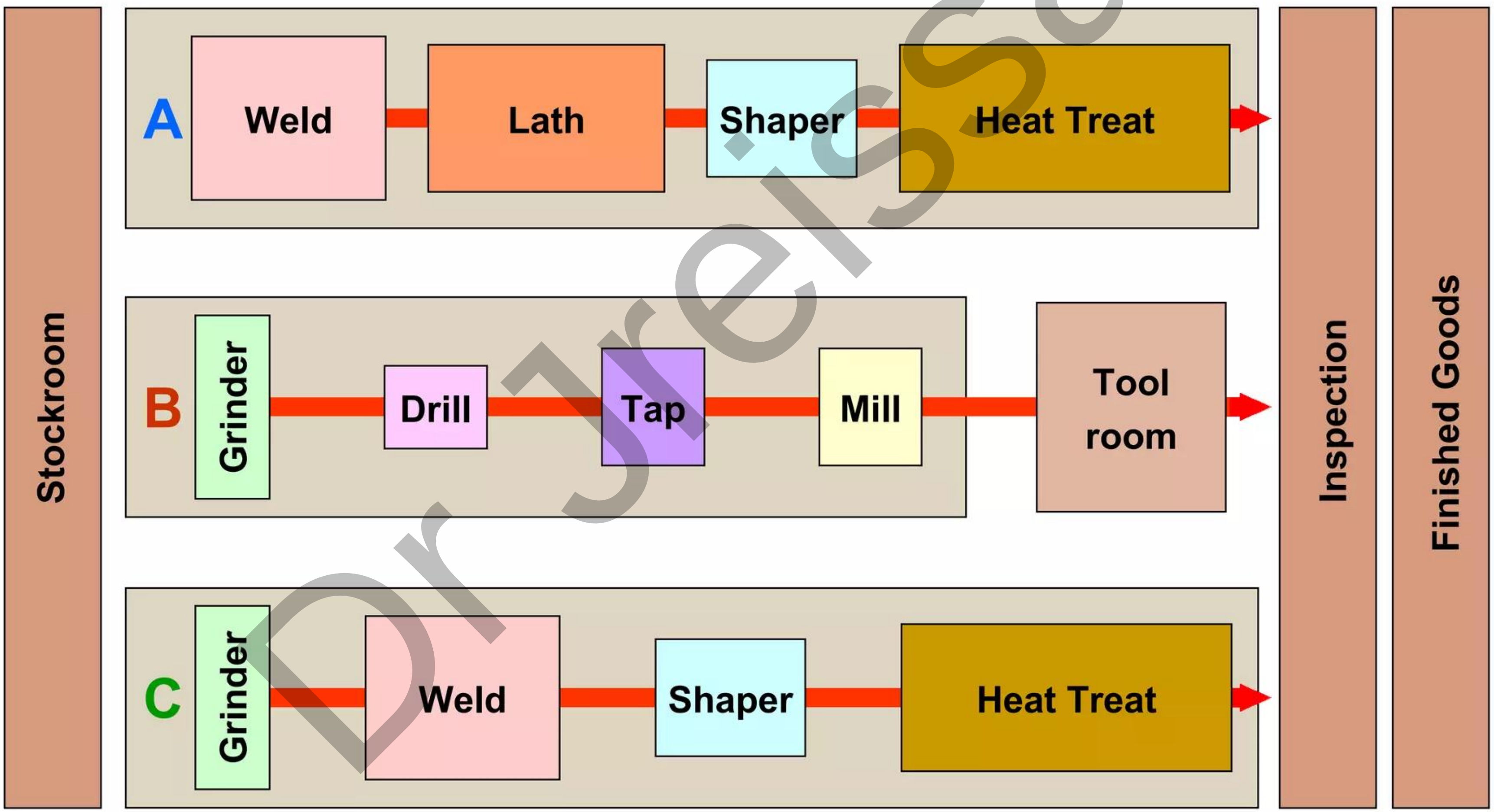
Should use pull/kanban

Batch Manufacturing

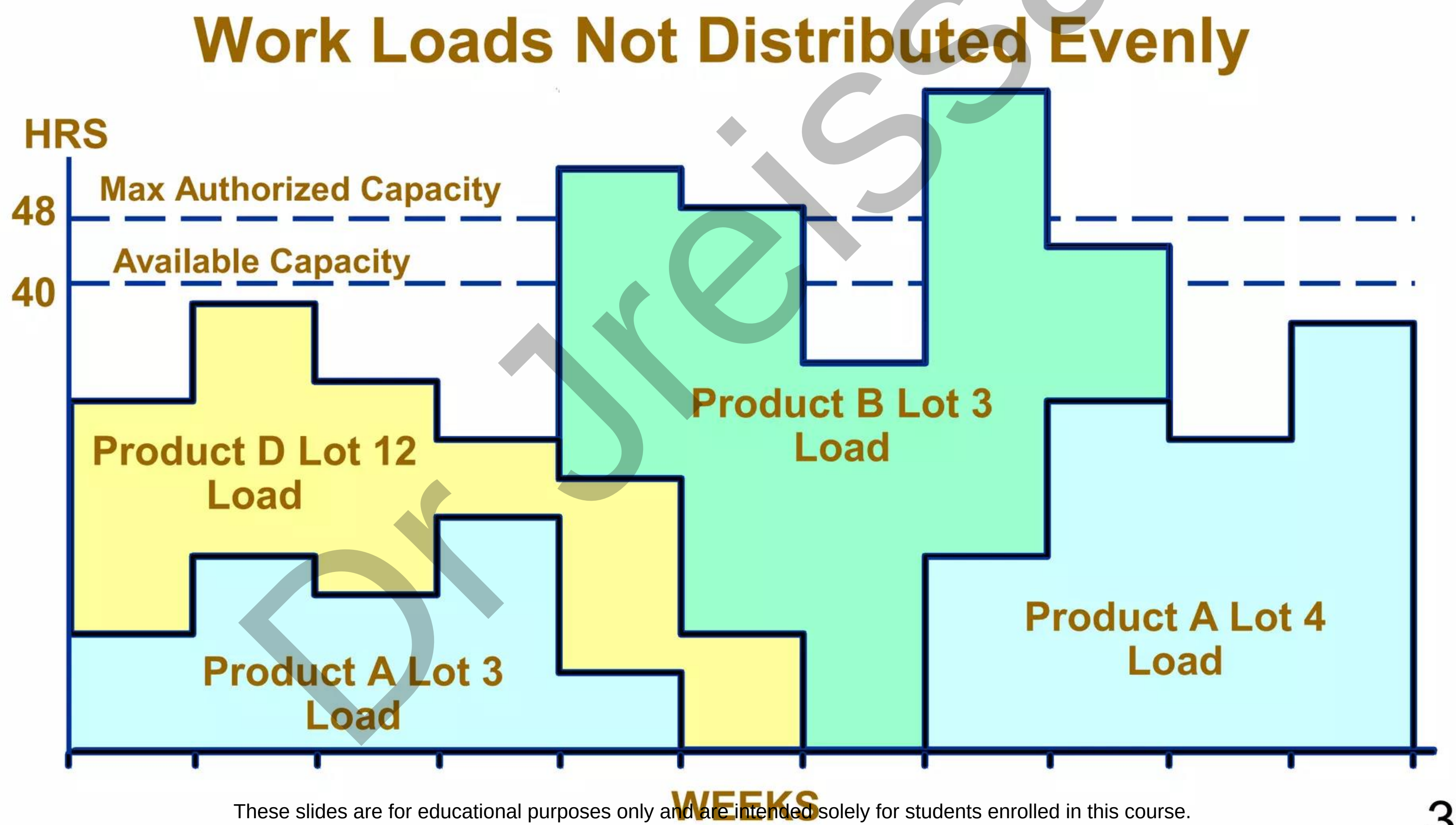


Using Production Lines

LEAN SIG

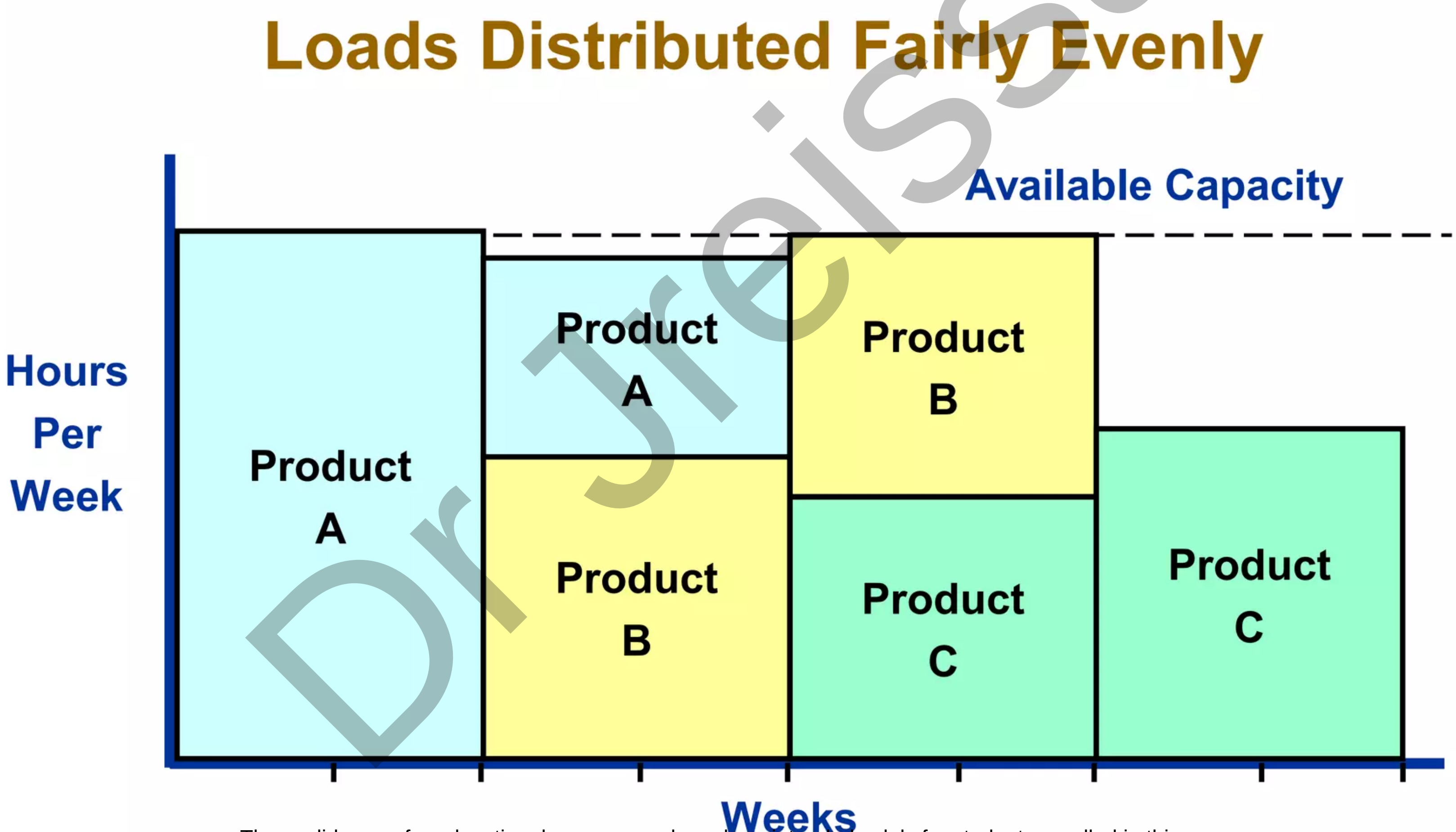


Loads Not Leveled



Loads Leveled

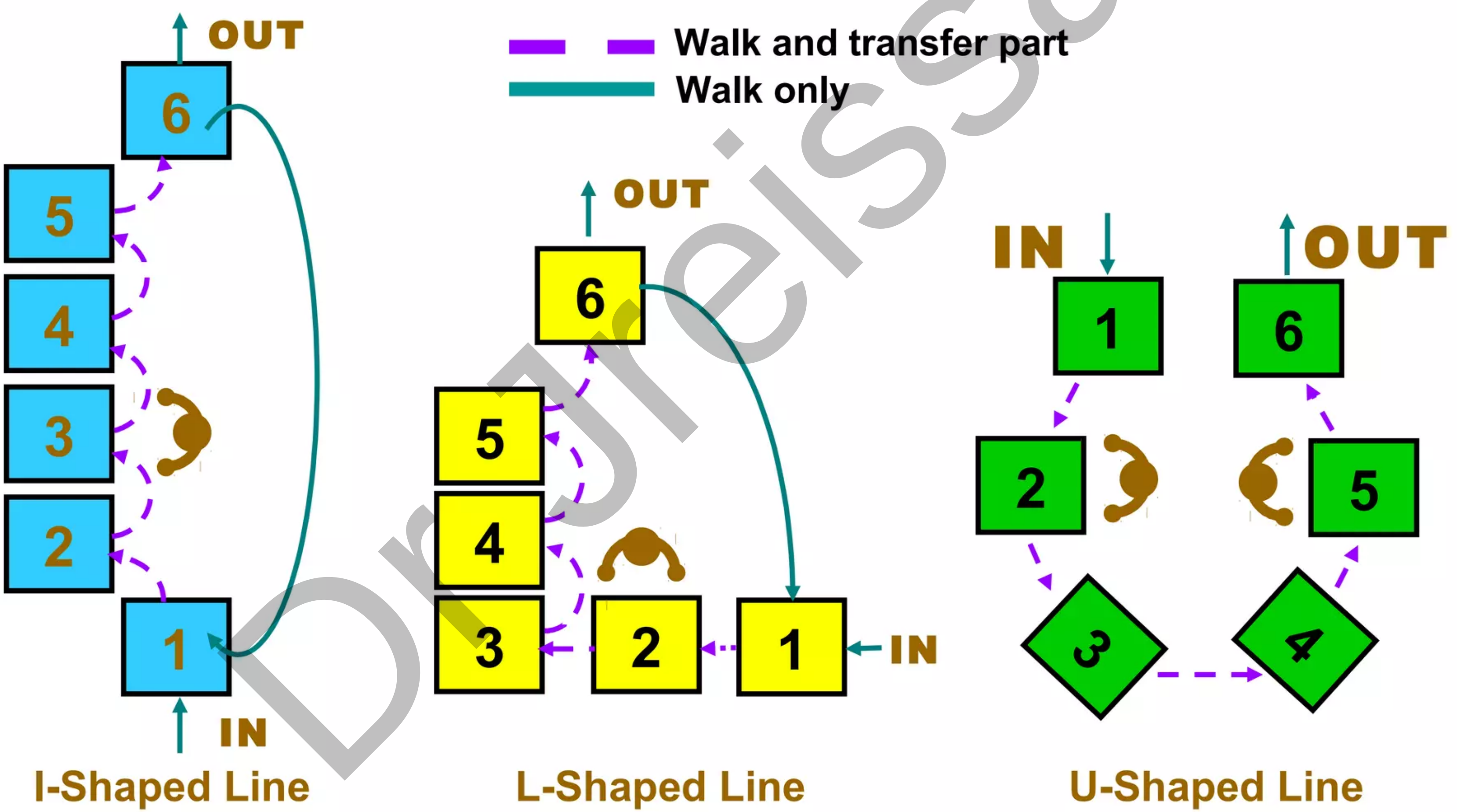
LEANSIG



Cellular Manufacturing

- **An approach to producing a family of parts or products on a dedicated line with dedicated operators**
  - **Functional layouts are rearranged into process oriented cells.**
  - **Machines and workstations are linked.**
  - **Layouts are designed for efficient flow.**
  - **All operator requirements are close by.**

Production Cell Varieties



Lean must be Designed into the system

- **A lean company ideally starts with the lean design of its products.**
  - **Products should be designed by taking into consideration their manufacturing and assembly requirements at the same time they are being designed.**
  - **Use concurrent or simultaneous engineering.**

Design for One-Piece Flow

Stop producing big batches of product and start producing one piece at a time

1. Focus on the part, product or service itself. Follow the product through its entire production cycle looking for opportunities to reduce delay, inventory, waste, and rework.

In a <u>hospital</u> you would follow a patient from admission to discharge.
In a <u>printing company</u>, you'd follow a job from start to delivery.
In a <u>manufacturing plant</u>, you'd follow the product from order to delivery.

Design for One-Piece Flow

2. Ignore traditional boundaries, layouts, etc. In other words, forget what you know.

3. Realign the work flow into production "cells" to eliminate delay, rework, and scrap.

4. "Right size" the machines and technology to support smaller batches, quick changeover, and one-piece flow. This often means using simpler, slower, and less automated machines that may actually be more accurate and reliable.

The goal of flow is to eliminate all delays, interruptions and stoppages, and not to rest until you succeed.

Focus the improvement effort to avoid wasting valuable time and money.

Focus on mission- and profit-critical processes and issues first!

Definition

Just-in-Time—Process of producing only what is needed, when it is needed, and only at the quantity needed.

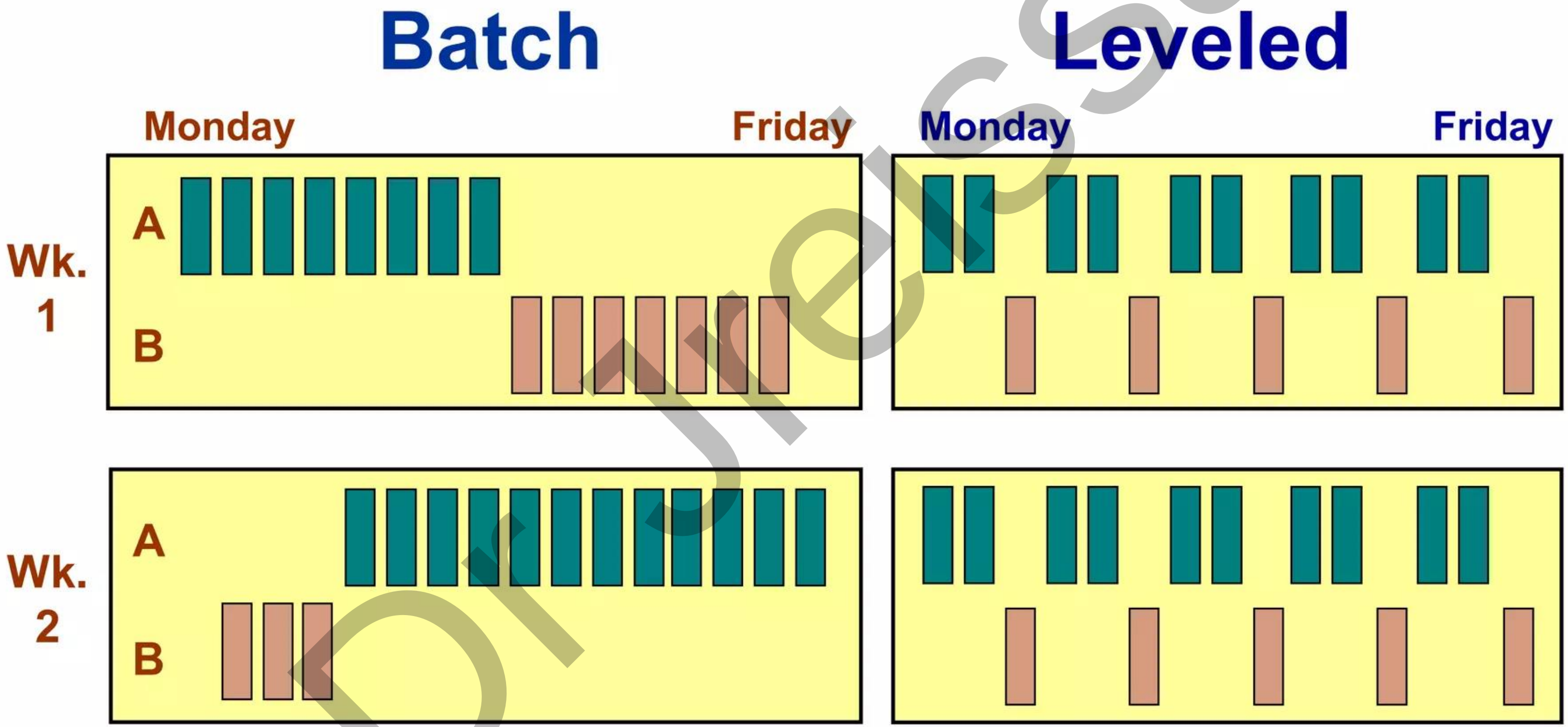
Pull System

1. In manufacturing: the production of items only as demanded to replace those taken.
2. In material control: withdrawal of inventory as demanded by a user. Material is not issued until a signal is received from the user.
3. In distribution: a system for replenishing field warehouse inventories where replenishment decisions are made at the field warehouse itself and not at the central warehouse or plant.

– APICS Dictionary, 10th edition

Load Leveling Material/Labor

LEANSIG

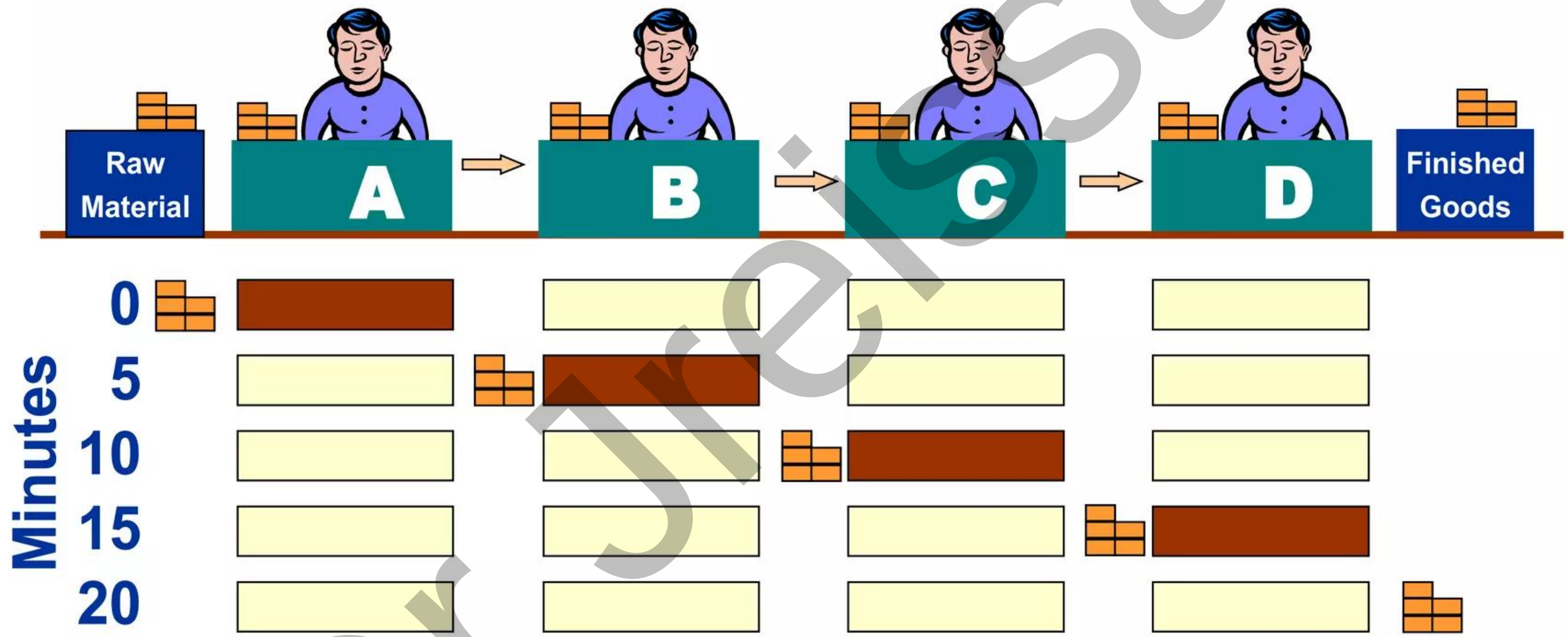


Assume A is three times more complex than B

Material and labor leveled

Batch Flow

LEAN SIG

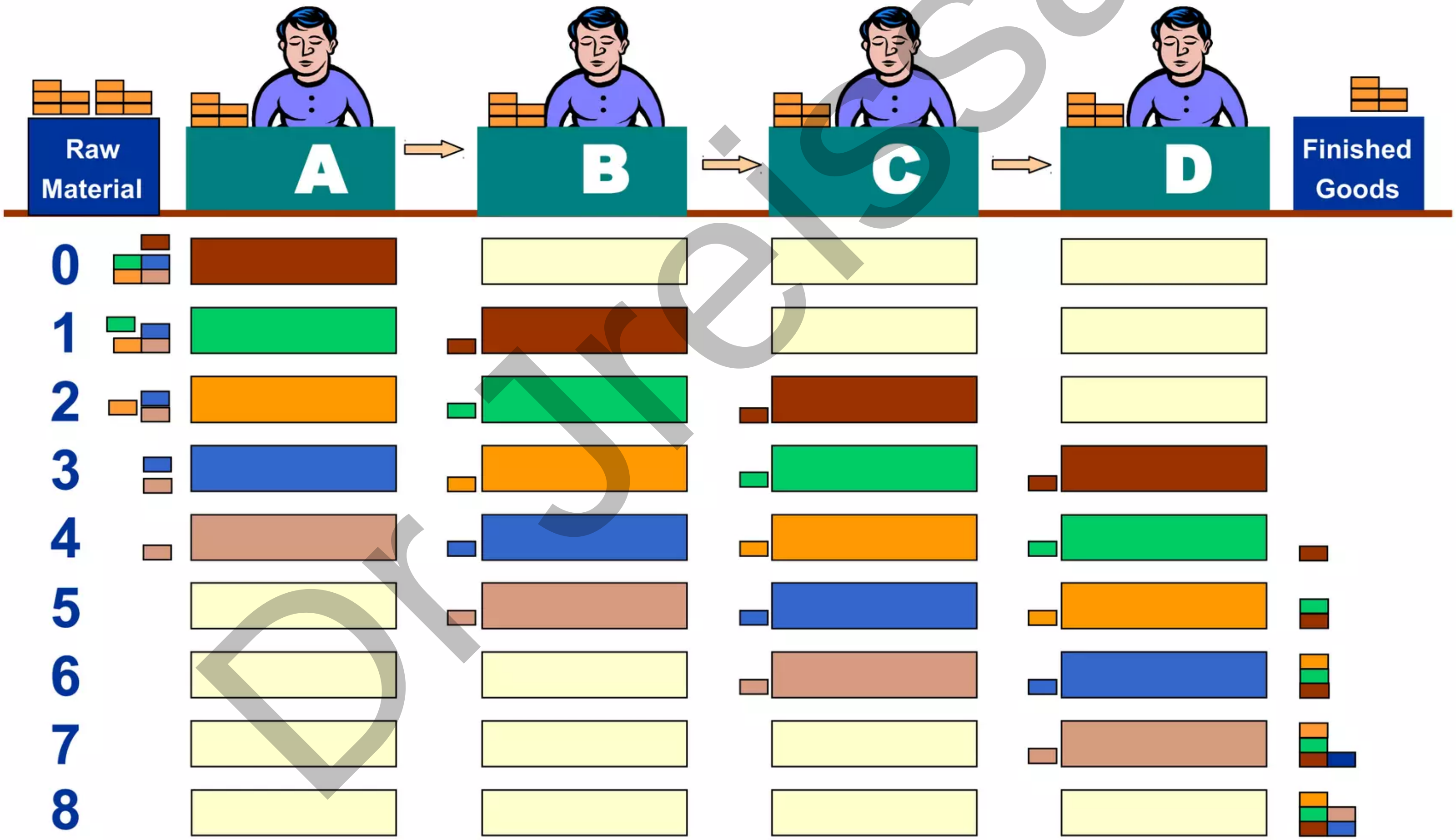


20 Minutes Total Lead Time for 5 Units

Processing time = 1 minute per unit

Single-Piece Flow

LEAN SIG



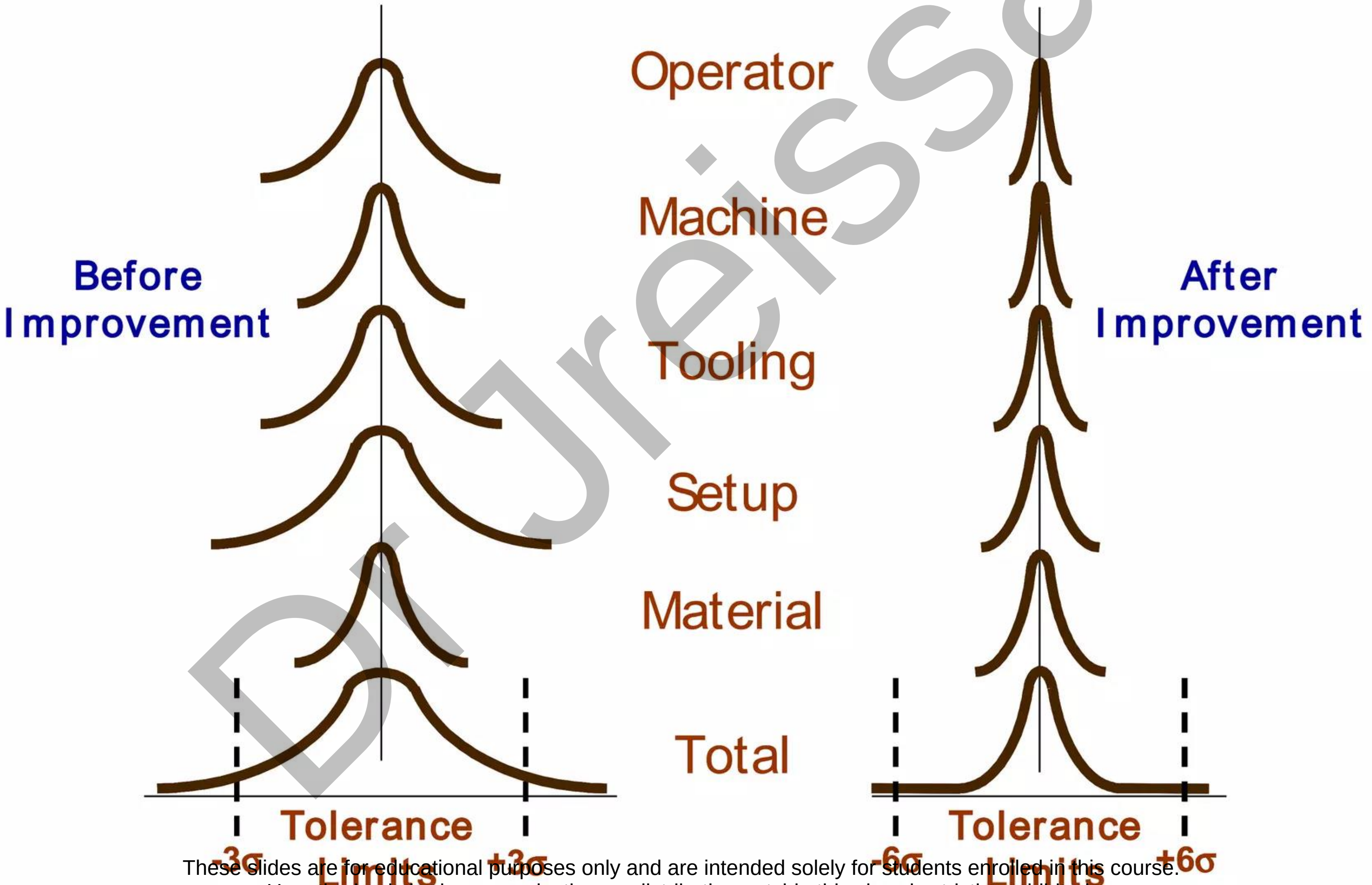
8 minutes total lead time for five units

Self-Verification Benefits

LEAN SIG

Defects Found At:	Own Process (Self-Verification)	Next Process	End of Line	Final Inspection	End User
Cost to the Company:					
Impact to the Company:	• Very Minor	• Minor Delay	• Rework • Reschedule of Work	• Significant Rework • Delay in Delivery • Additional Inspection	• Warranty Cost • Administration Cost • Reputation • Loss of Market

Continuous Improvement
Sources of Process Variability



Value-Stream Mapping (VSM)

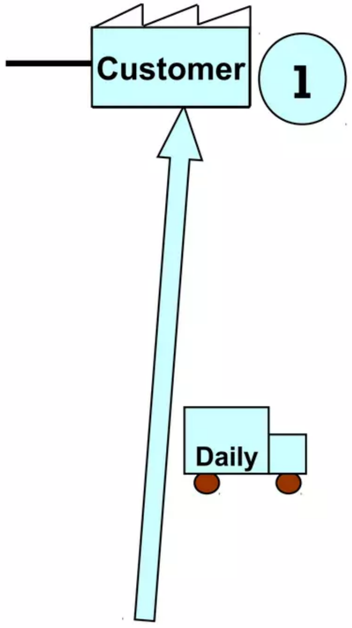
- Start by observing and recording the flows of orders, materials, goods, and information for a product family.
  - Product family: A group of product variants passing through similar processing steps that use common equipment.
- One objective of mapping is to elevate waste situations for later improvements.

Value-Stream Mapping Process

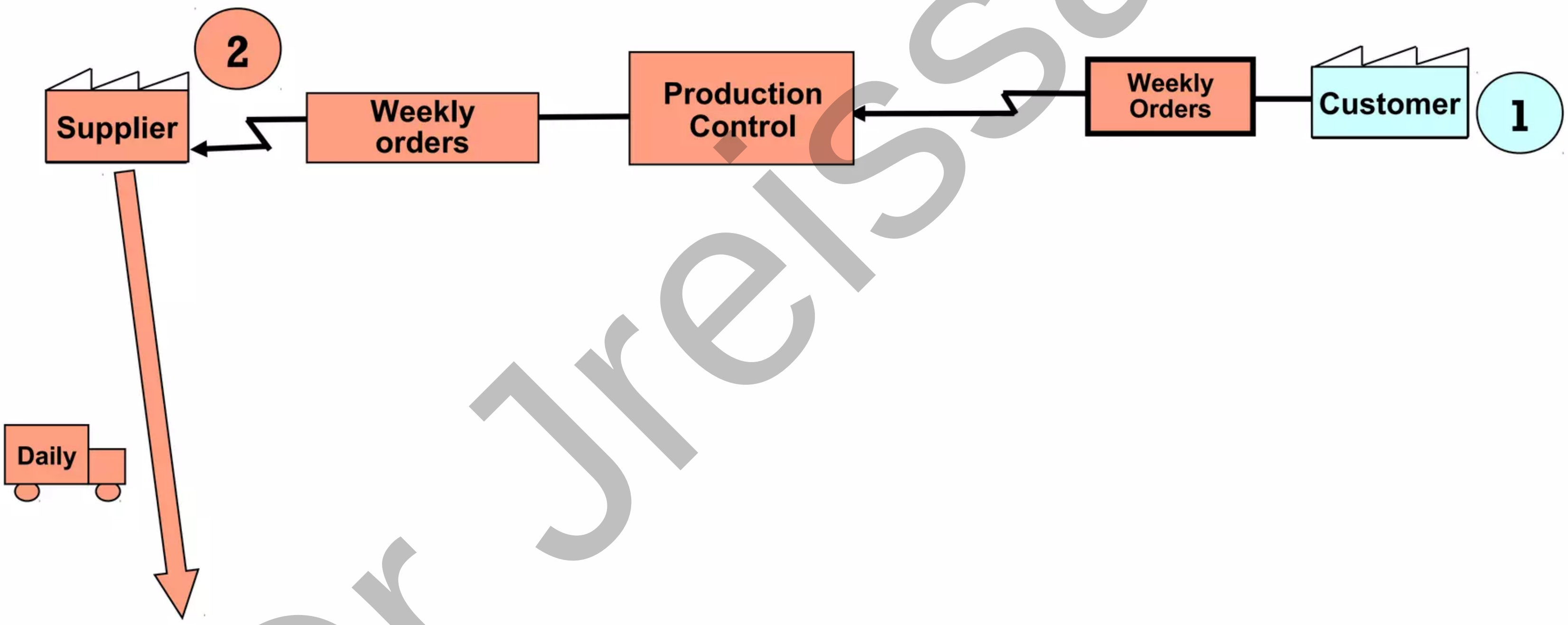
1. Map customer requirements (orders)
2. Map order information flows
3. Map physical product/material flows
4. Map plant information flows
5. Add a process time line
6. Summarize current state

Ask questions at each step to help determine waste or non-value-added areas.

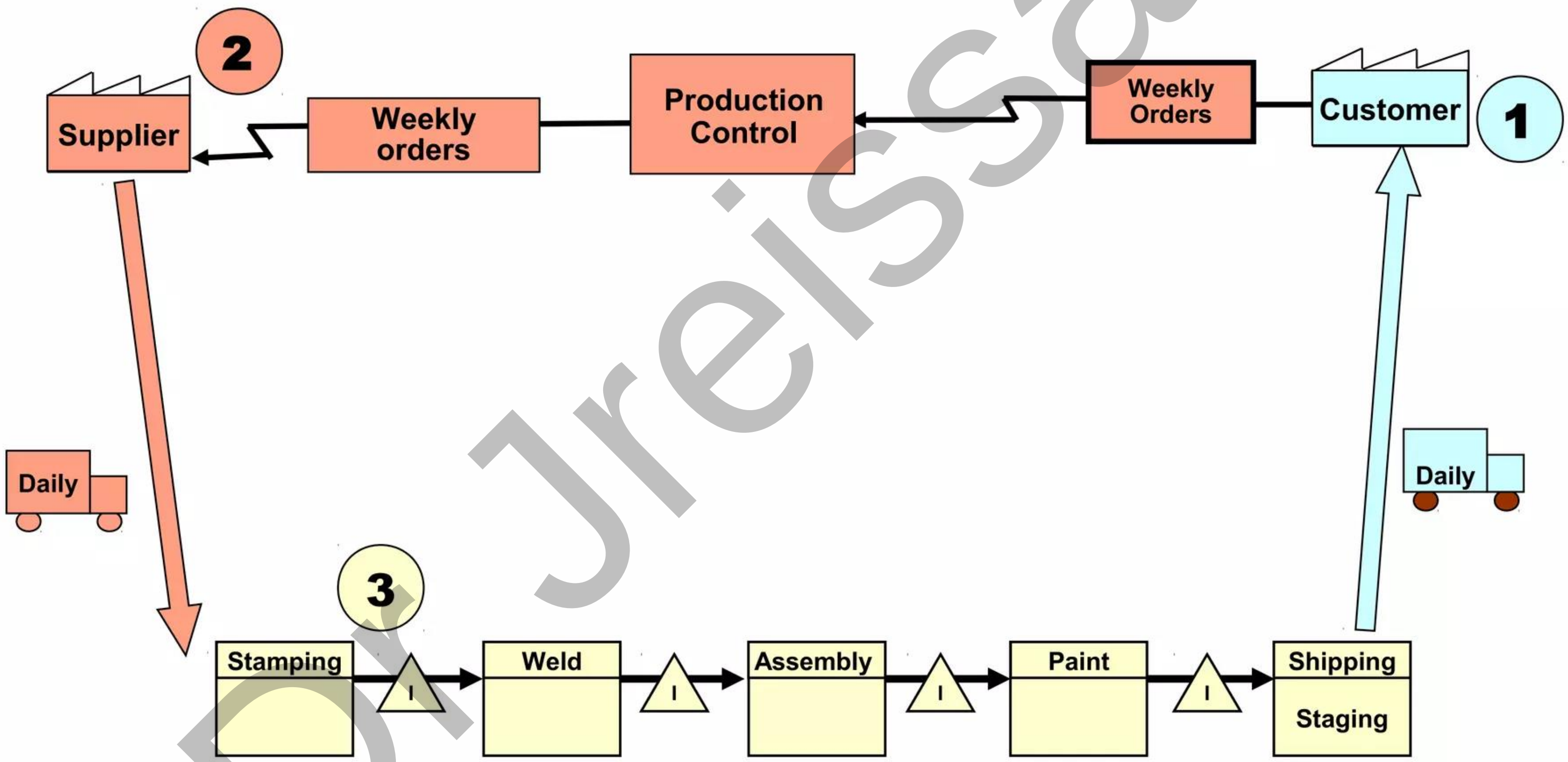
1. Map Customer Requirements



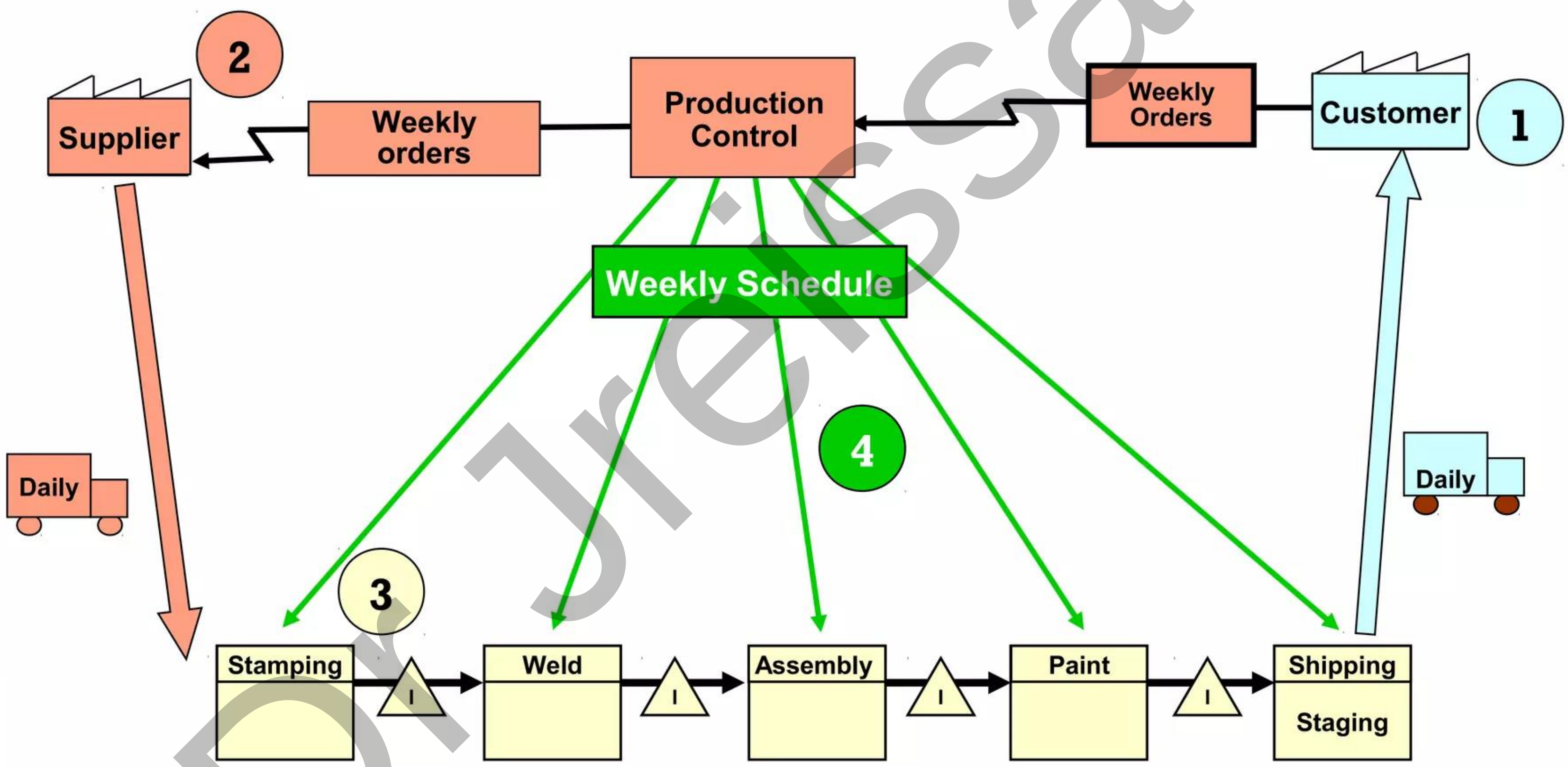
2. Map Order Information Flows



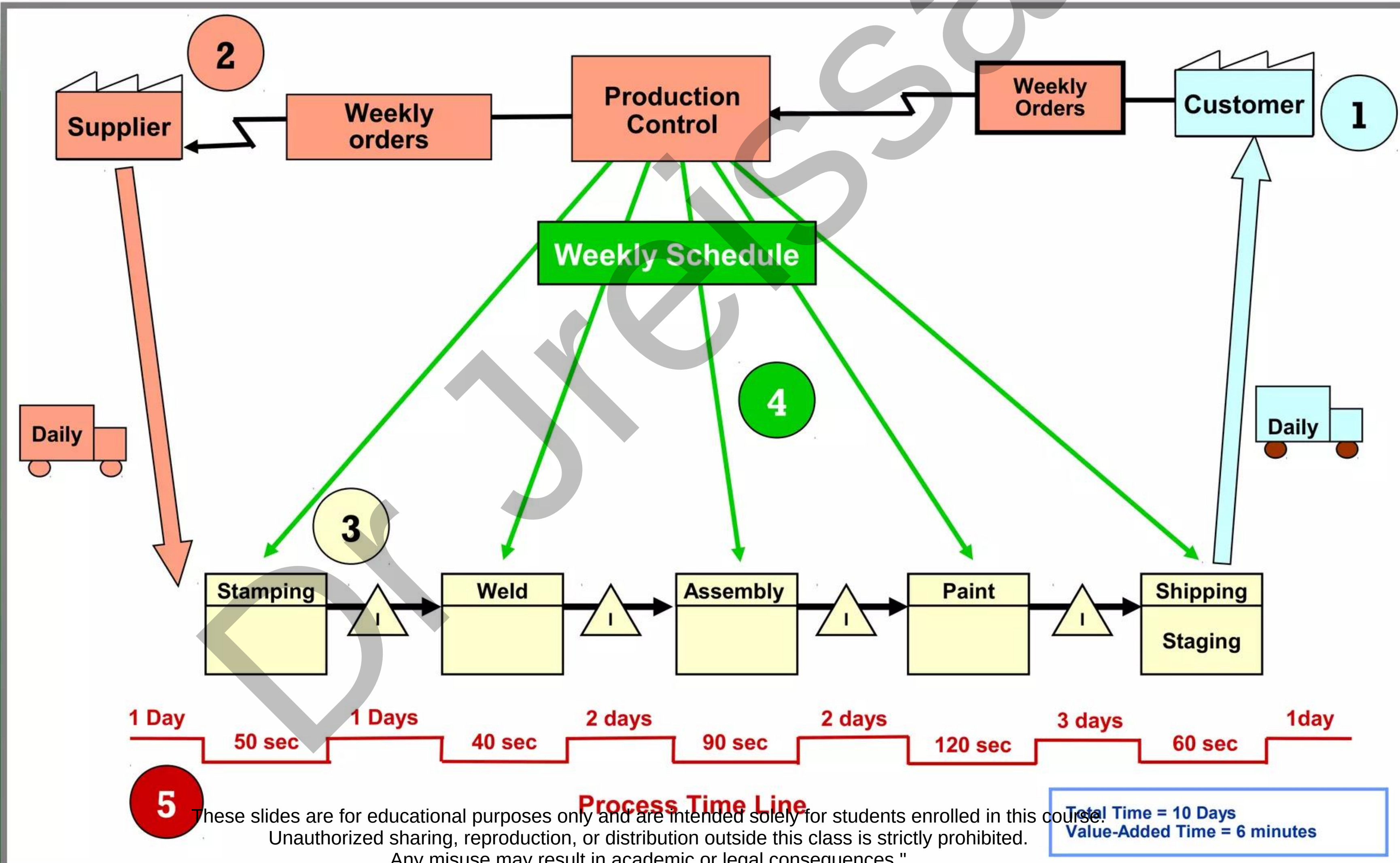
3. Map Physical Product Flows



4. Map Plant Information Flows



5. Add a Process Time Line



Getting Started

- Reorganize your company by product and value stream. Topple the silos and implement flow.
- Move machines and people into product cells.
- Help your remaining suppliers implement "Lean."
- Improve each value stream multiple times.
- Right-size your machines and tools.

Why Lean?

"It's not necessary to change. Survival is not mandatory."

– W. Edwards Deming

Definitions

Cell	A close arrangement of people and machines in a processing sequence to facilitate flow
Kanban	Japanese word for card, ticket, or sign. It's a key tool for managing flow in a pull system. In a grocery store, it's the card at the back of the shelf indicating the product is sold out or back ordered.
Andon	Visual signal that alerts workers to problems. Andon is like a dashboard with warning lights to alert you to problems.
Heijunka	Level out the work load.
Jidoka	Automation with the human touch.
Takt Time	In lean, takt is the rate of customer demand. It's like a speedometer. Takt Time = Available hours worked per day/Required production to meet demand.
Poka-Yoke	Mistake-proofing a process so that a person cannot make an error.

TYPES OF ACTIVITY/WORK

- **VALUE ADDED** - For which customer pays and necessary.

  E.g.-Actual Operation (Riveting, Bending)

- **NON VALUE ADDED** - For which customer doesn't pay but needed.

  E.g.-Inspection , WIP

- **WASTE** – Does not needed.

  E.g.- Defects, Delays, Manpower Idle

Lean Manufacturing

CONCEPT

WASTE FREE PRODUCTION

BY ELEMINTAING WASTES & REDUCING NON-VALUE ADDED WORK

Lean Manufacturing

Definition of Lean-Manufacturing

-Systematic Elimination of Waste

-Reduction of "FAT" From Production Activities

-Half the Hours of Human Efforts

-Half the Factory Space for same Output

- A Tenth or Less of In Process Inventories

"**LEAN IS… A mindset, or way of thinking, with a commitment to achieve a totally waste-free operation that's focused on your customer's success**

Tools of Lean-Manufacturing

1- 5 ‘S’
2- Andon
3- Bottleneck Analysis
4- Continious Flow
5- Gemba
6- Heijunka
7- Jidoka
8- JIT
9- Kan-Ban
10- Kaizen
11- KPI (Key Performance Index)

Lean Manufacturing

Tools of Lean-Manufacturing

12- Muda (Waste)

13- OEE (Over All Equipment Effectiveness)

14- PDCA

15- Poke-Yoke

16- Root Cause Analysis

17- SMED

18- Six Big Losses

19- Standardized Work

20- TAKT Time

21- TPM

22- Value Stream Mapping

Tools of Lean-Manufacturing

23- Smart Goals

24- Hoshin Kanri

25-Visual Factory

Lean Manufacturing

1- 5 'S'

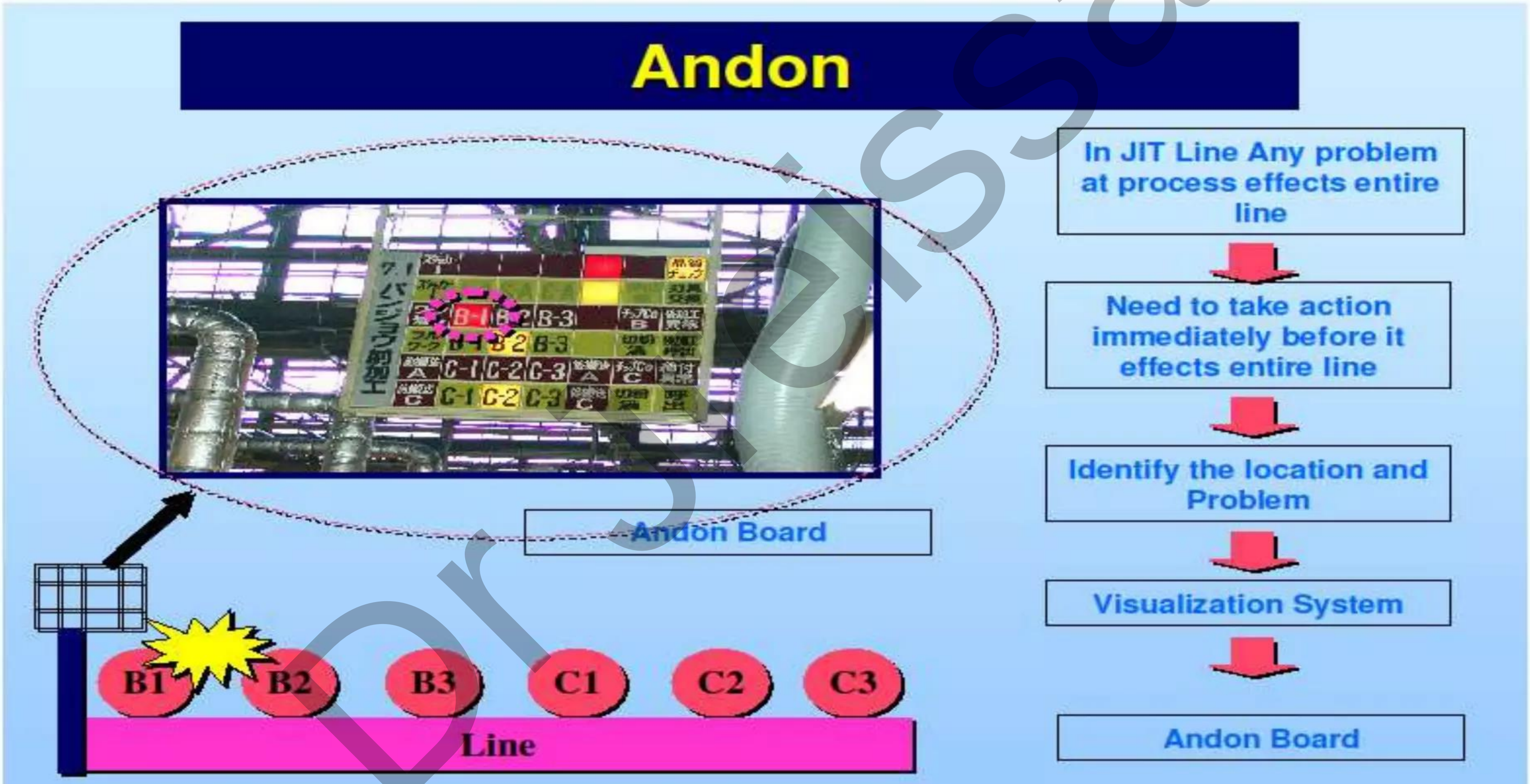
Organize the work area:

- **Sort (eliminate that which is not needed)**
- **Set In Order (organize remaining items)**
- **Shine (clean and inspect work area)**
- **Standardize (write standards for above)**
- **Sustain (regularly apply the standards)**

2- Andon

Visual feedback system for the plant floor that indicates production status, alerts when assistance is needed, and empowers operators to stop the production process.

2 A- Andon

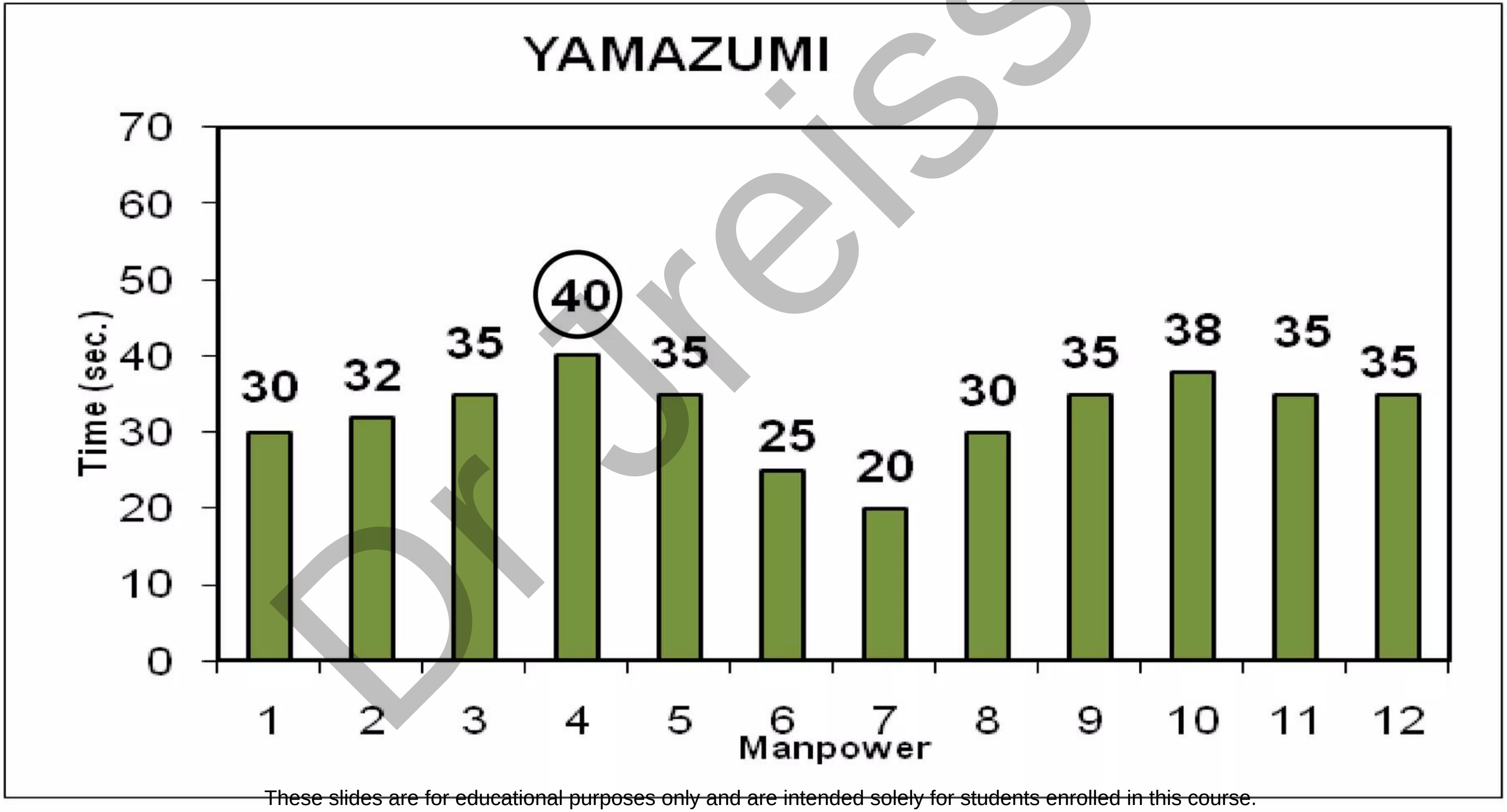


- Andon is a Management tool to Visualize abnormality at work place.

3 -Bottleneck Analysis

Identify which part of the manufacturing process limits the overall throughput and improve the performance of that part of the Process

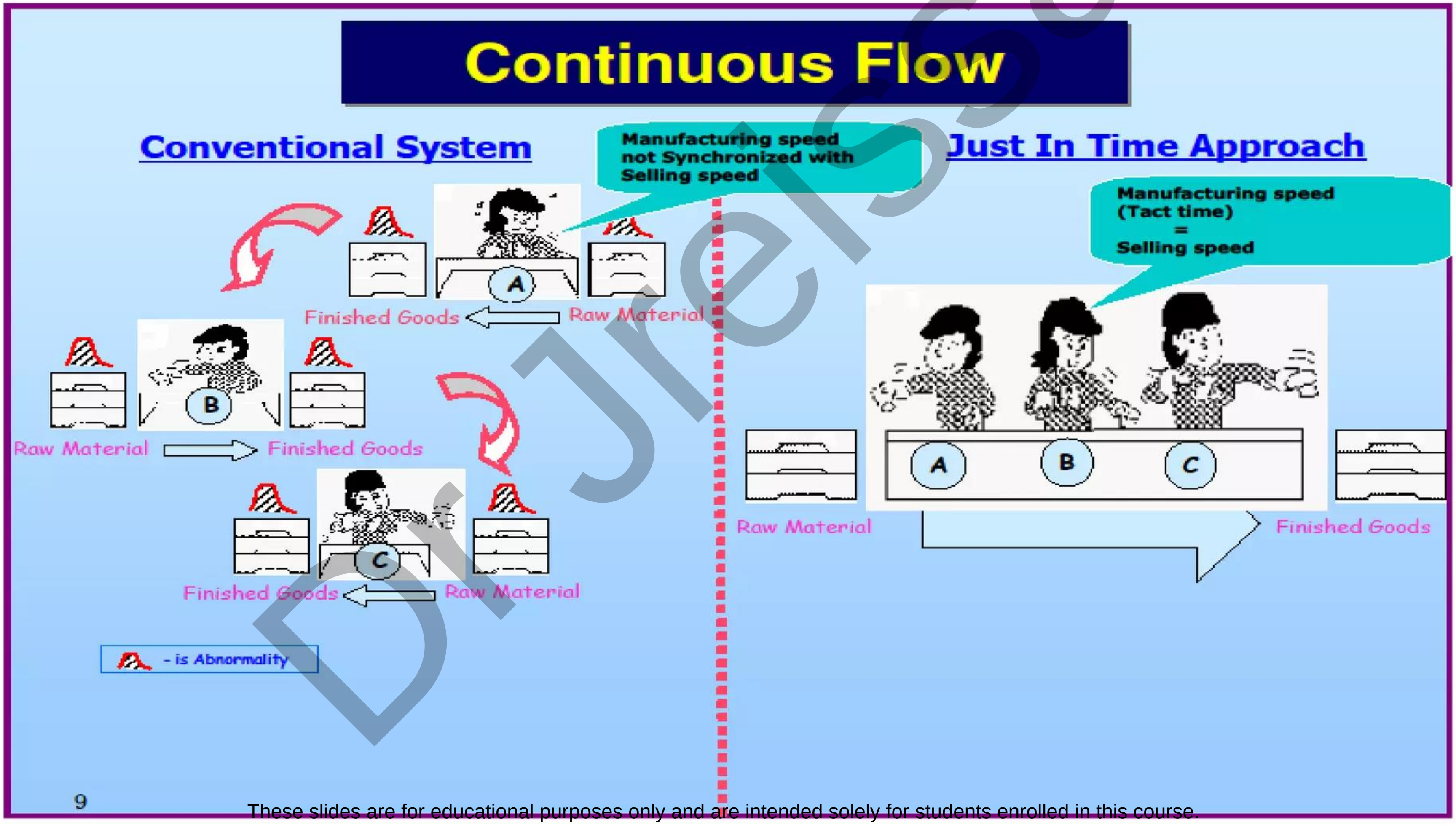
3 A – Bottleneck Analysis



4 – Continuous Flow

Manufacturing where work-in-process smoothly flows through production with minimal (or no) buffers between steps of the manufacturing process.

4 A – Continuous Flow



5 – Gemba

A philosophy that reminds us to get out of our offices and spend time on the plant floor – the place where real action occurs

6 – Heijunka

A form of production scheduling that purposely manufactures in much smaller batches by sequencing (mixing) product variants within the same process.

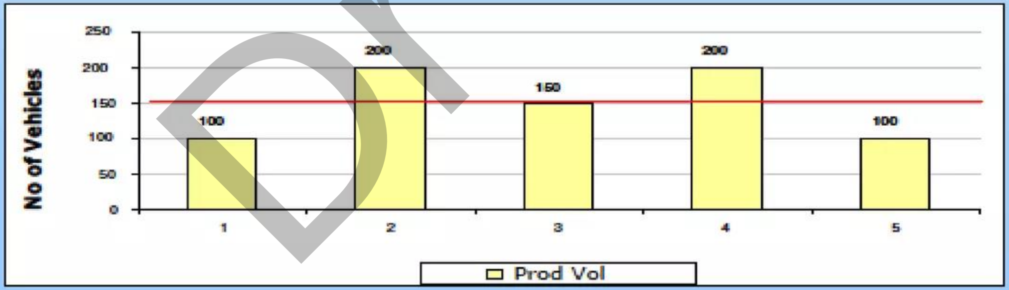
6 A – Heijunka

What is Heijunka ?

Leveling of fluctuation in the model or amount of work in the process.

Why Heijunka is required ?

1. Optimum utilization of the resource.
2. To reduce manufacturing lead time.
3. To Maintain the standardize work.
4. To Satisfy all type of customers



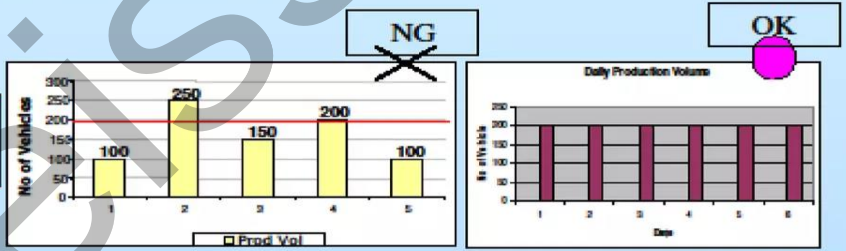
6 B – Heijunka

How Heijunka is done ?

1. Leveled production of total daily production quantity

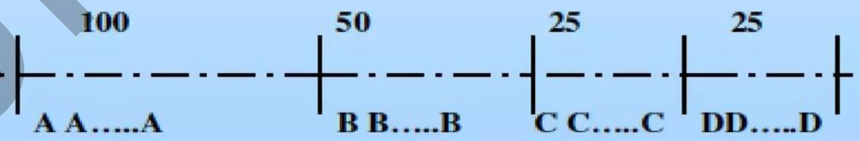
Dealers Demand	
Model	**Qty**
A	2000 Units / Month
B	1000 Units / Month
C	500 Units / Month
D	500 Units / Month
Total	4000 Units / Month

→ 20 Days Working → Daily Production Volume = 200 units/day



2. Leveling of different models in daily production

	Qty Required	Ratio
STD (A)	100	4
DLX (B)	50	2
GDLX (C)	25	1
PDLX (D)	25	1
Total	200	



3. Standardization of production sequence

Based upon the ratio , Heijunka is done for the sequence

7 – Jidoka

Design equipment to partially automate the manufacturing process (partial automation is typically much less expensive than full automation) and to automatically stop when defects are detected.

Lean Manufacturing

7 B – Aims of Jidoka

Aims of Jidoka

1. Building 100% quality in at all times
2. Failure prevention of machinery & equipment
3. Manpower savings (No need monitoring of machinery)

3 Basic Types of Jidoka Systems

1. Fixed Position Line stop
2. Pokoyoke
3. Andon

8 – JIT (Just In Time)

Pull parts through production based on customer demand instead of pushing parts through production based on projected demand. Depends on many lean tools, such as Continuous Flow, Heijunka, Kanban, Standardized Work and Takt Time.

- **Produce and convey what customers want, when they want in exactly the amount they want.**

Lean Manufacturing

8 A – JIT (Just In Time)

Just In Time

"3" Operating Principles to establish the JIT in manufacturing and conveying process

1. Tact time
2. Continuous flow process
3. Pull system

9 – Kaizen

A strategy where employees work together proactively to achieve regular, incremental improvements in the manufacturing process.

Kai + Zen = Better + Change

SHIVANI

Example of Kaizen

Format No : F020S062/00

Deptt: Mfg **Shop/Area: Punto Acctuator** **Line/Station: Line no-3** **Date: 02-01-14**

Operation/ Machine	Kaizen Theme	Counter Measure	Benefits
Crimping of wire with terminal	5'S'	A hole is made on table	5'S' improved

KAIZEN Diagram

Before KAIZEN	After KAIZEN
Operator was putting scrap of wire on table and scrap of wire were spreaded on table	A hole is made on table for putting scrap and A red bin is placed for collecting scrap part

Kaizen Area : 1- Productivity 2- Quality 3- Work Standardization
4- 5'S' 5- Safety 6- Customer satisfaction

10 – Kan-Ban

A method of regulating the flow of goods both within the factory and with outside suppliers and customers. Based on automatic replenishment through signal cards that indicate when more goods are needed.

Lean Manufacturing

SHIVANI

10 A – Calculation of Kan-Ban

SHIVANI LOCKS PVT LTD													DEPTT.-FG STORE
KANBAN CALCULATION (DOMESTIC) FOR STOCK CONTROL BOARD													
				(green)	BETWEEN RUNNING AND MAX				MONTH- DEC-2014				
				(yellow)	BETWEEN MIN AND RUNNING								
				(red)	BELOW MIN AND ABOVE MAX								
S. NO.	TKM Part no	Shivani part no	Part name	ID	Month schedule (A)	Per day requirement (B)=A/25	Part/bin©	Min stock bin(one day)-D=B/C	Min stock bin (in round figure)	Running stock (DI)	Max stock=min stock+ running stock	Actual bins	Status
1	53510-0D170	AG01S-3000	Lock assy hood	ED06	5600	224	16	14.0	14	42	56		
2	64606-OD050	AG01S-6400	Lever sub assy	EY33	7200	288	35	8.2	9	27	36		
3	64610-0D050	AG02S-1800	Luggage compartment door	ED08	3200	128	23	5.6	6	18	24		
4	68610-0D080	AG01S-138000	check assy front door	ED10	14300	572	25	22.9	23	69	92		
5	68630-0D120	AG01S-139000	Check assy rear door	ED11	14300	572	25	22.9	23	69	92		
6	69350-0D110	AG01S-1800	Lock assy back door	ED12	4000	160	18	8.9	9	27	36		

Lean Manufacturing

10 B – Example of Kan-Ban


INTERNAL KANBAN

Customer: M/S Toyota Kirloskar Motor Pvt

Model: 800L

From: LINE " C"

Part No: 686300D12000

To: Rack " µ "

Description: Check Assy Rear

Dispatch

ED11

Qty / Bin

25

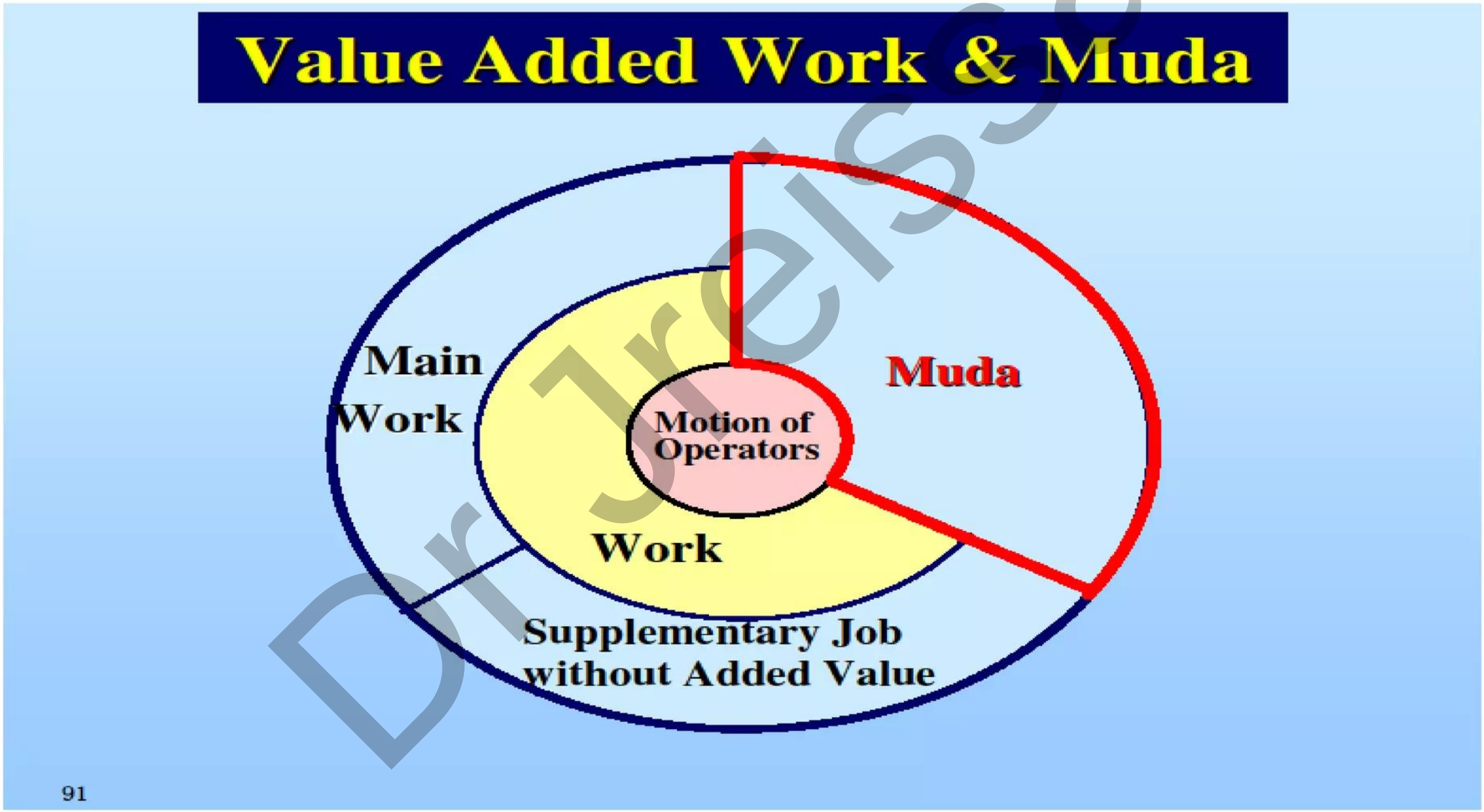
11 – KPI (Key Performance Index)

Metrics designed to track and encourage progress towards critical goals of the organization. Strongly promoted KPIs can be extremely powerful drivers of behavior – so it is important to carefully select KPIs that will drive desired Behavior

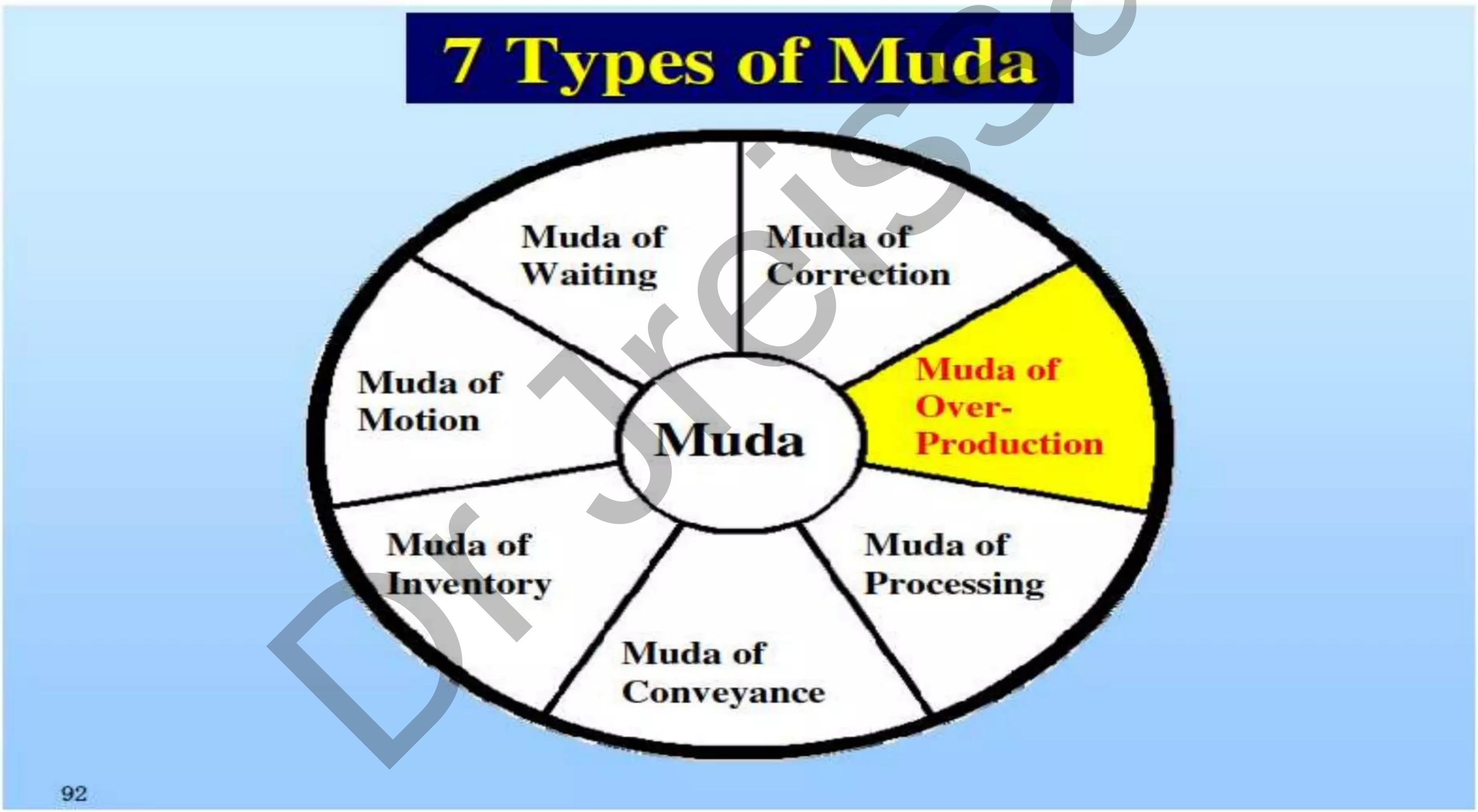
12 – Muda(Waste)

Anything in the manufacturing process that does not add value from the customer's perspective

12 A – Muda(Waste)



12 B – Muda(Waste)



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12 C – Muda(Waste)

There are seven type of Wastage-

1- Transportation
2- Inventory
3- Motion
4- Waiting
5- Over Production
6- Over Processing
7- Defects

These are also known as "TIM WOOD"

13 – OEE (Over All Equipment Effectiveness)

Framework for measuring productivity loss for a given manufacturing process. Three categories of loss are tracked:

- **Availability (e.g. down time)**
- **Performance (e.g. slow cycles)**
- **Quality (e.g. rejects)**

Lean Manufacturing

13 – OEE (Over All Equipment Effectiveness)

Framework for measuring productivity loss for a given manufacturing process. Three categories of loss are tracked:

- **Availability (e.g. down time)**
- **Performance (e.g. slow cycles)**
- **Quality (e.g. rejects)**

13 A – Example for Calculating OEE

OEE= Availability x Quality x Productivity

Availability-

Total Time Available	=450 Minutes
Time Loss due to Any Reasons	= 50 Minutes
Total Time Utilized	= 400 Minutes
Availability %Age	= 400/450
	= 88.9 %

Quality-

Total Part Produced	= 1200 Pcs
Rejection Part	= 10 Pcs
OK Parts Produced	= 1190 Pcs
Quality %Age	= 1190/1200
	= 99.2%

13 A – Example for Calculating OEE

Productivity-

Total Time Utilized	=400 Minutes
Part produced in Target Time	= 1200 Pcs
Actual Part Produced	= 1150 Pcs
Productivity %Age	= 1150/1200
	= 95.8 %

OEE = 88.9 x 99.2 x 88.9/1000000

= 845019/1000000

= 0.845

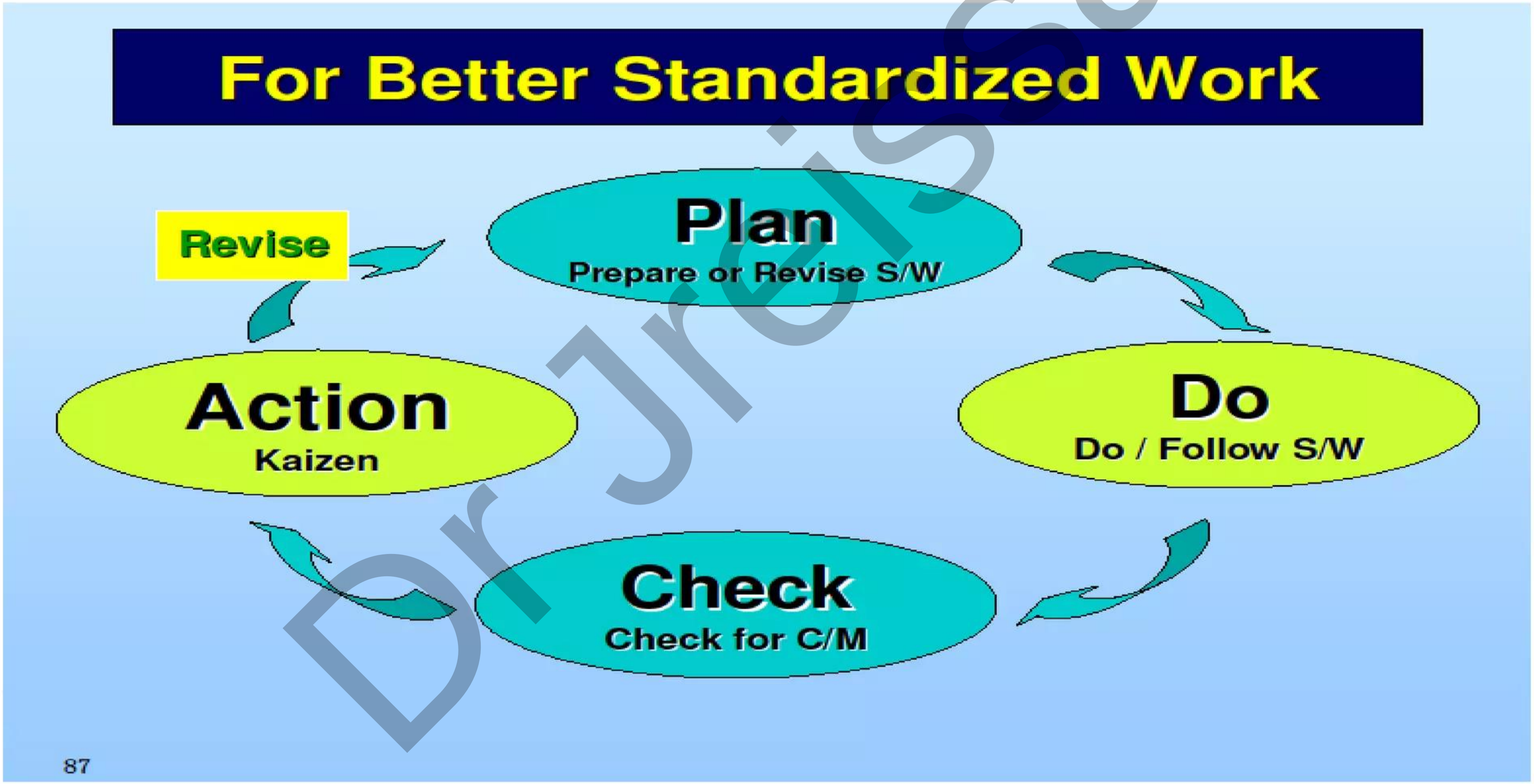
=84.5%

14 – PDCA (Plan,Do,Check & Action)

An iterative methodology for implementing improvements:

- Plan (establish plan and expected results)
- Do (implement plan)
- Check (verify expected results achieved)
- Act (review and assess; do it again)

14 – PDCA (Plan,Do,Check & Action)



15 – Poke Yoke

Design error detection and prevention into production processes with the goal of achieving zero defects.

15 A – Poke Yoke

Types of Poke Yoke

1-Detection Poke Yoke
2-Prevention Poke Yoke

Based on Theory that-

1-Don't accept NG Part
2-Don't produce NG Part
3-Don't pass the NG Part

16 – Root Cause Analysis

A problem solving methodology that focuses on resolving the underlying problem instead of applying quick fixes that only treat immediate symptoms of the problem. A common approach is to ask why five times – each time moving a step closer to discovering the true underlying Problem

17 – SMED (Single Minute Exchange Die)

Reduce setup (changeover) time to less than 10 minutes. Techniques include:

- -Convert setup steps to be external (performed while the process is running)
- -Simplify internal setup (e.g. replace bolts with knobs and levers)
- -Eliminate non-essential operations

Create standardized work instructions

18 – Six Big Losses

Six categories of productivity loss that are almost universally experienced in manufacturing:

- Breakdowns
- Setup/Adjustments
- Small Stops
- Reduced Speed
- Startup Rejects
- Production Rejects

19 – Standardized Work

Documented procedures for manufacturing that capture best practices (including the time to complete each task). Must be "living" documentation that is easy to change.

19 A – SWCT

SHIVANI LOCKS PVT LTD.

STANDARDIZED WORK COMBINATION TABLE (SWCT)

Part name :-	Door Check Front & Rear	Model :-	800L	Loop No. :	1	Takt Time (Sec.)
Part No :-	AG01S-138000/139000	Process Name / No :-	Sub assy of shoe & cushion with case / 20	Prep. Date	10/18/2011	Cycle Time (Sec.)

CT=17 TT=22 Operation Time (Unit: Sec

Sequence	Element	Manual	Auto	Walk	Total
1	Pick the cup from LH hand	1	6		
2	Inspection for tapping & Plating	1			1
3	pick the Greese brush	1			2
4	Take greese & Greesing Inside the cup	3			3
5	Keep the greese brush	1			6
6	pick Ist shoe & sub assy with cup	2			7
7	pick IInd shoe & sub assy with cup	2			9
8	pick ist cushion & sub assy with cup	2			11

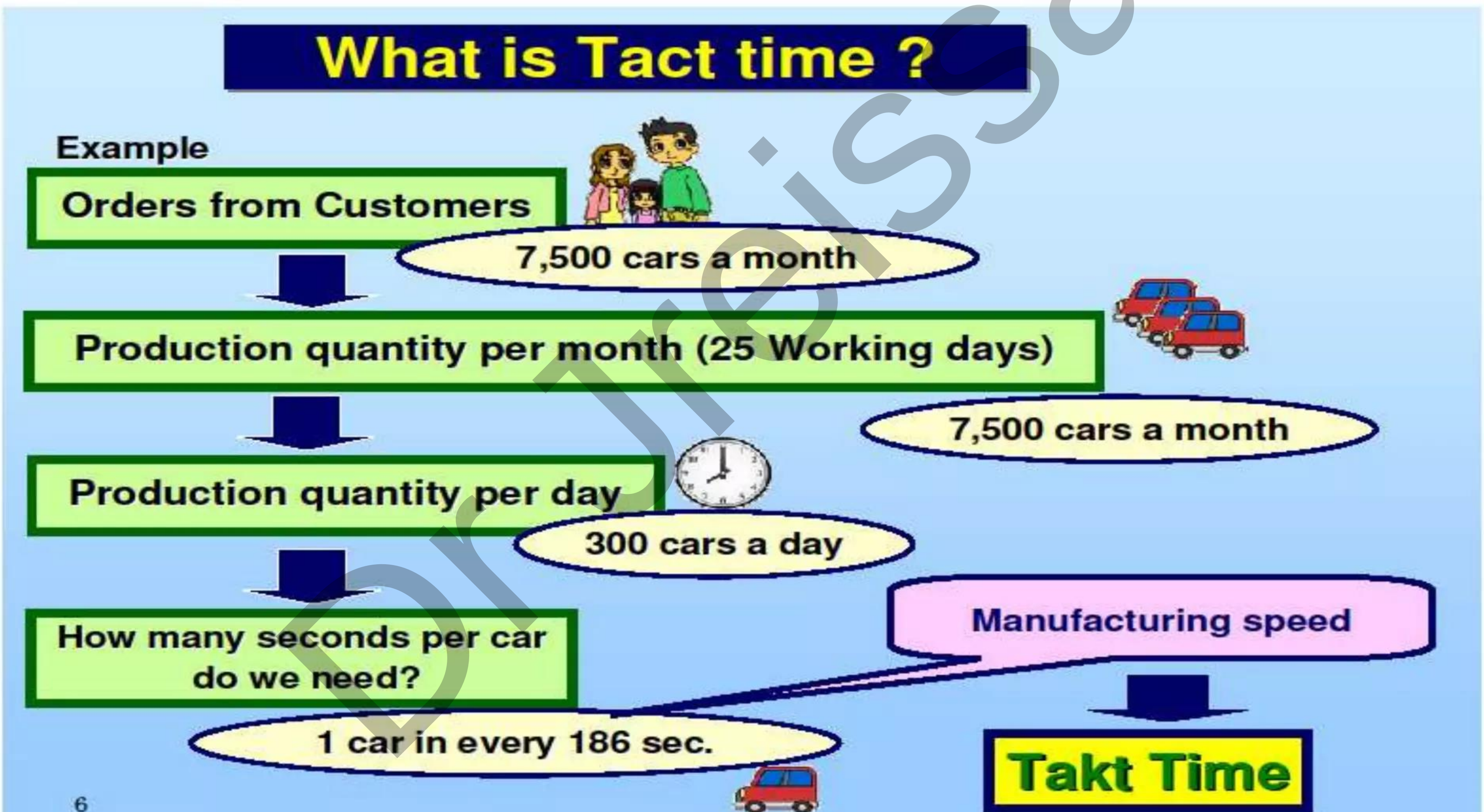
Operation time scale (secs): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

IDEAL TIME 5 sec.

20 – Takt Time

The pace of production (e.g. manufacturing one piece every 34 seconds) that aligns production with customer demand. Calculated as Planned Production Time / Customer Demand.

20 A – Takt Time



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20 B – Takt Time

21 – TPM

A holistic approach to maintenance that focuses on proactive and preventative maintenance to maximize the operational time of equipment. TPM blurs the distinction between maintenance and production by placing a strong emphasis on empowering operators to help maintain their equipment.

21 – TPM

TPM in three words:

T	Total	• Overall efficiency. • Total production system. • Participation of all employees.
P	Productive	• Zero defect. • No trouble in operation. • Safety.
M	Maintenance	• Longer life cycle of production system.

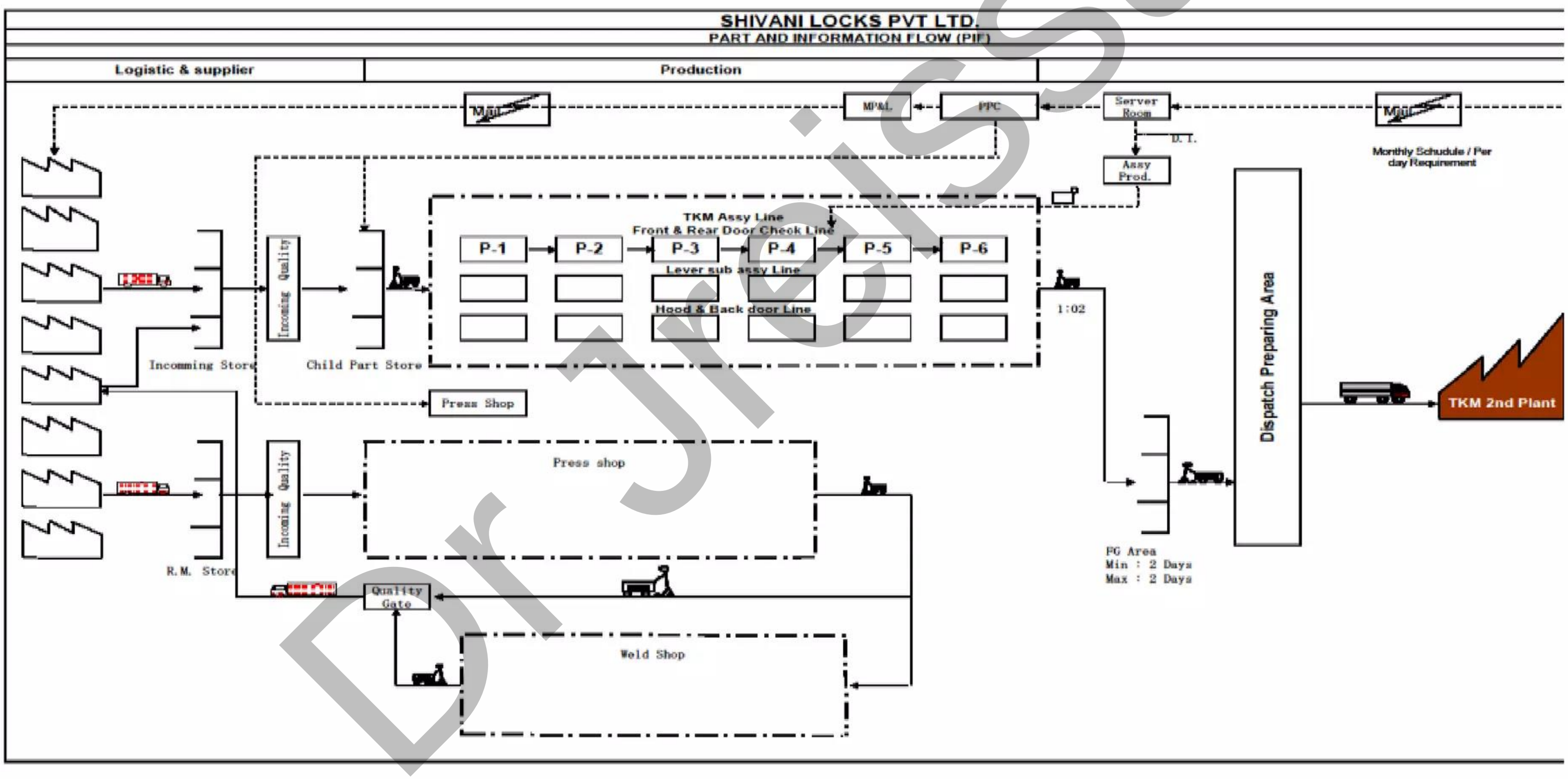
21 A – PILLARS OF TPM

22 – Value Stream Mapping

A tool used to visually map the flow of production.

Shows the current and future state of processes in a way that highlights opportunities for improvement

22 – Value Stream Mapping



23 – Smart Goals

Goals that are: Specific, Measurable, Attainable, Relevant, and Time-Specific.

24- Hoshin Kanri

Align the goals of the company (Strategy), with the plans of middle management (Tactics) and the work performed on the plant floor (Action).

25- Visual Factory

Visual indicators, displays and controls used throughout manufacturing plants to improve communication of information.