



**LEAN**

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# INTRODUCTION

---

fig. 1

| Muda                       | Mura                   | Muri                   |
|----------------------------|------------------------|------------------------|
| Manufacturing Waste Events | Unevenness of Workflow | Overburden             |
| Non-Value-Added Activity   | Reduces Responsiveness | Reduces Responsiveness |
| Incurs Cost                | Leads to Waste Events  | Leads to Waste Events  |



## CHAPTER 1

### Six Components of Lean Philosophy

---

fig. 2



fig. 3

### Traditional Supply Chain Interpretation

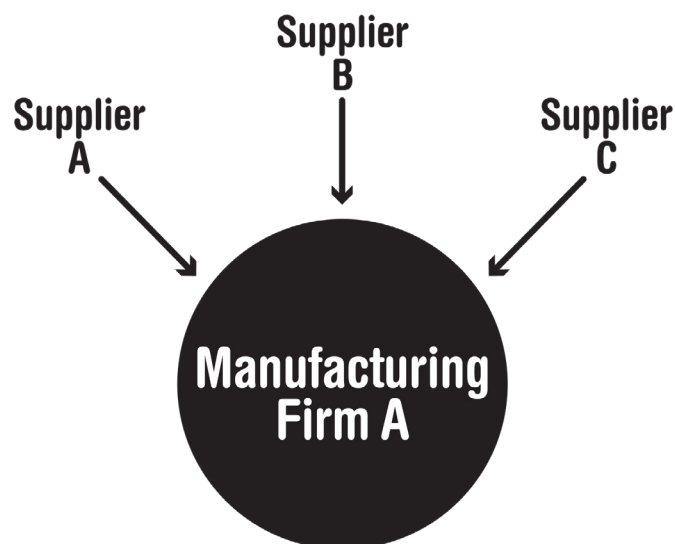


fig. 4

## Network Supply Chain Interpretation

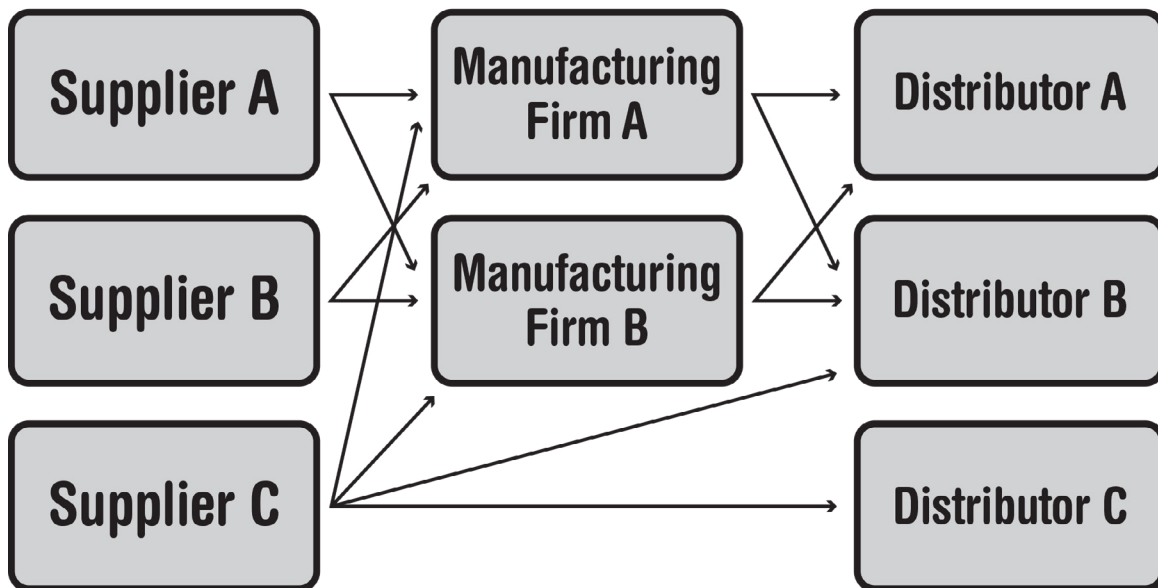


fig. 5

## Hierarchy of Organizational Planning



fig. 6

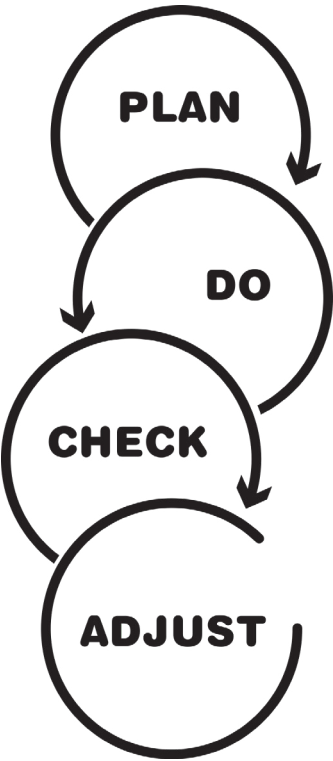


fig. 7

**Title :** What are you talking about?

|                            |                                   |
|----------------------------|-----------------------------------|
| Date : <i>Latest Draft</i> | Owner : <i>Preparer of the A3</i> |
| Approval Date :            | Manager Approval :                |

**Background**

- Why are you talking about it?
- What is the business case? What business problem are you trying to solve or analyze? Be very concise – communicate *why* you are addressing this issue.

**Current Conditions**

- What is going on?
- Use facts and dates.
- Be visual – use Parelo charts, pie charts, sketches, etc.
- Make the problem clear.

**Goal**

- State the specific target(s). State in measurable or identifiable terms.

**Analysis**

- Use the simplest problem-analysis tool that will suffice to find the root cause of the problem: five whys; fishbone diagram, problem or process analysis tree, 7 QC tools (old or new), tools from the Six Sigma, Kepner-Tregoe, Shainen, Taguchi, TRIZ or other toolbox of your choice.

**Proposal**

- Your proposed countermeasures.

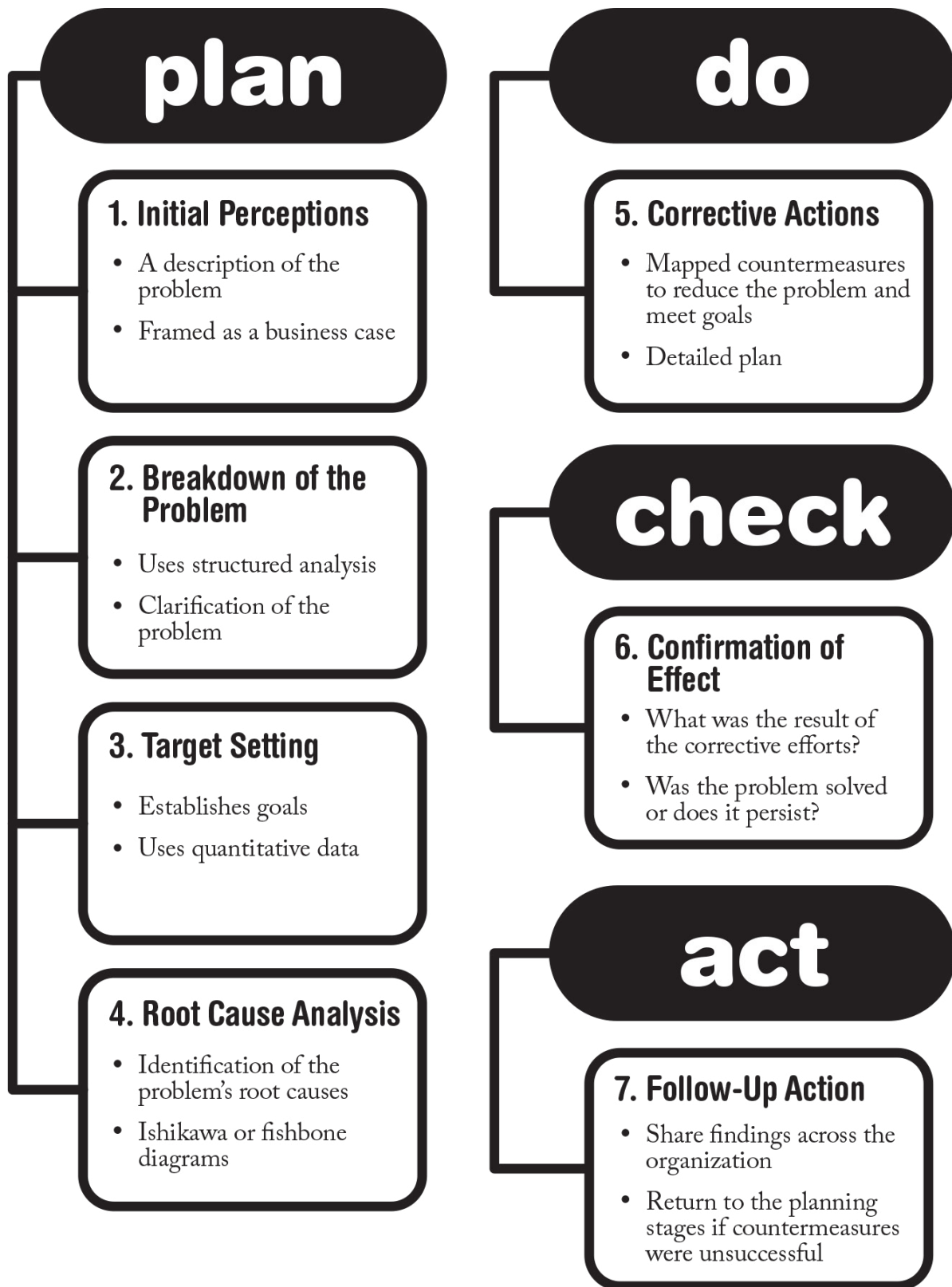
**Plan**

- Timeline with who, what, when, where, how.

**Follow Up**

- What issues or remaining problems can you anticipate?

fig. 8



# The Six Components of Lean Philosophy

## 1. Continual Elimination of Waste

- Identify the eight sources of waste
- Differentiate between value-added and non-value-added activities

## 2. Goals with a Broad View

- Goals drive tasks
- Tasks are matched with organizational objectives at all levels

## 3. Simplicity

- Simpler solutions are better solutions
- Complex problems exist as simpler, smaller problems

## 4. Continuous Improvement

- Learning from the past is growth
- Understand how all six philosophies are related and interdependent
- Understand that what you build today is the foundation for tomorrow

## 5. Organizational Visibility

- Visible problems are solvable; invisible problems are not
- Visibility at all levels encourages continuous improvement

## 6. Flexibility

- The organization must be ready to respond to a changing market environment
- The organization must be ready to respond to changing customer needs
- The organization must be prepared to restructure to survive

## CHAPTER 2

### Lean Production

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fig. 10

## The Pull Production System



fig. 11

## Value Stream Mapping

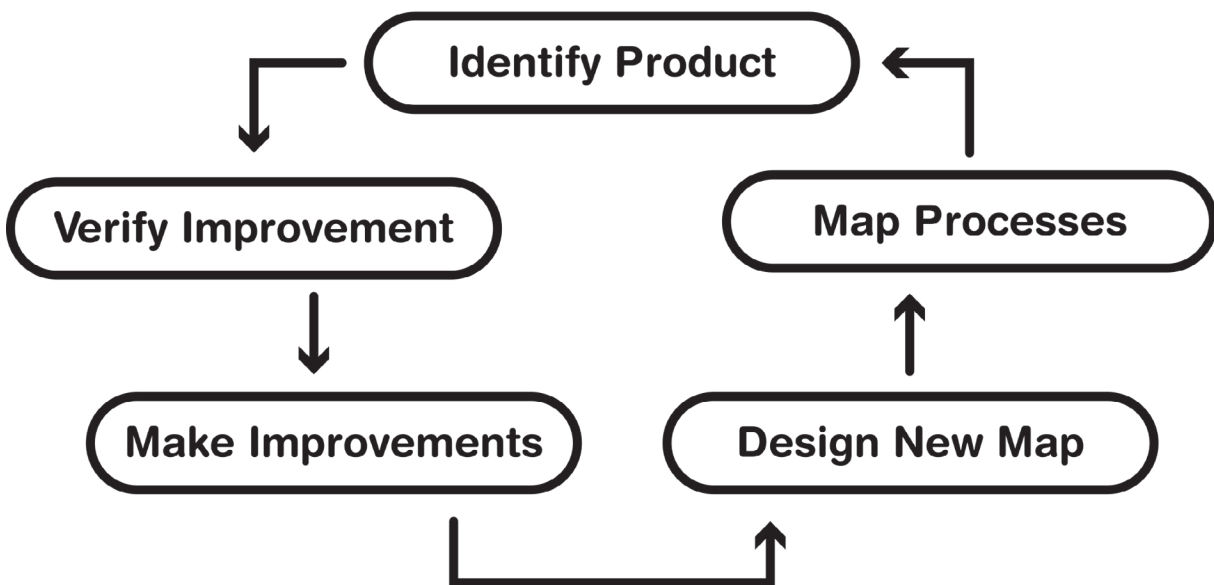


fig. 12

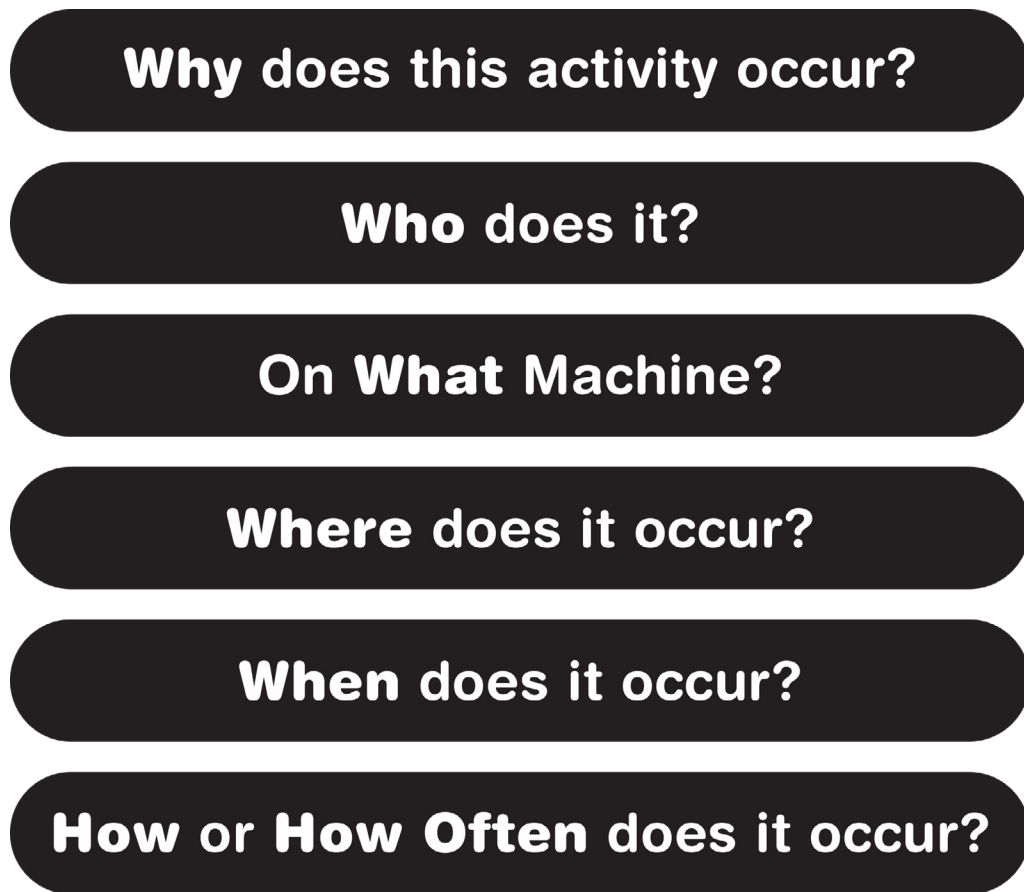


fig. 13

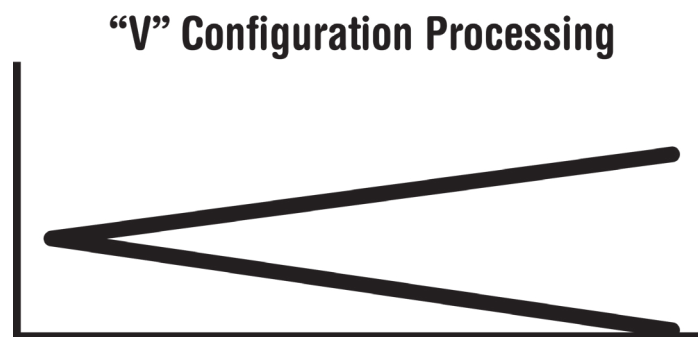


fig. 14

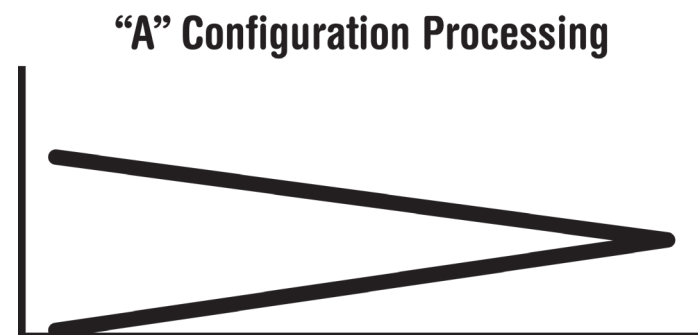


fig. 15

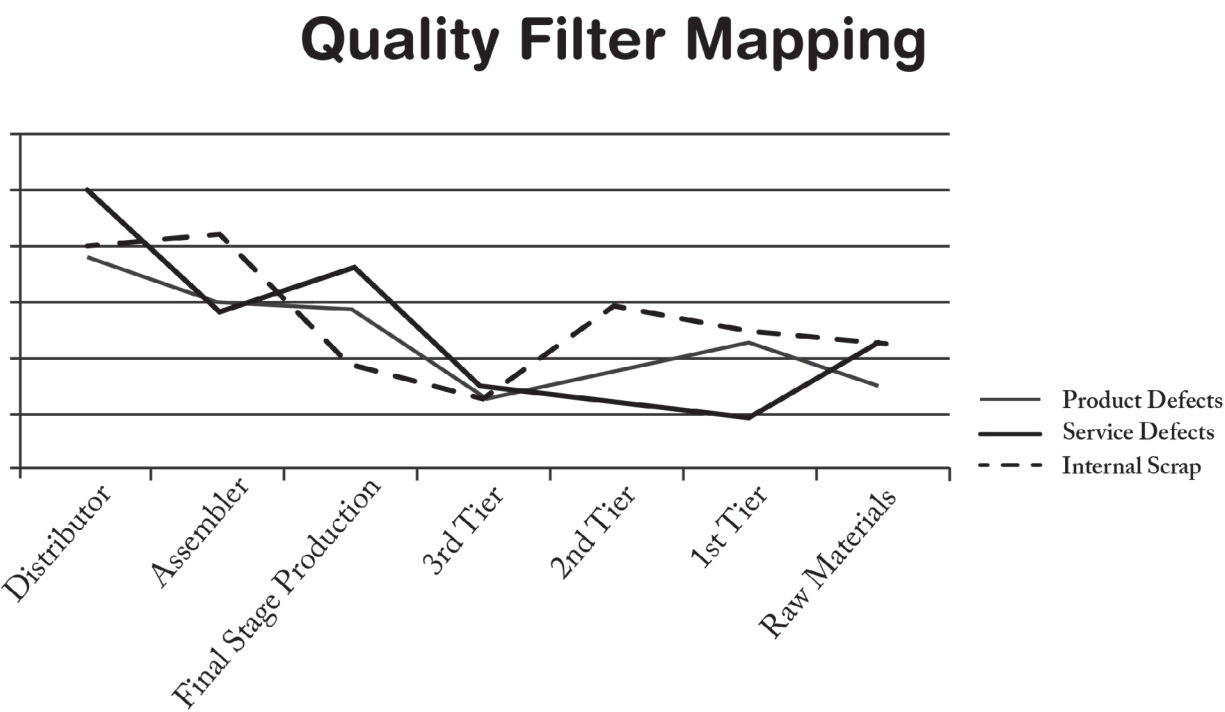


fig. 16

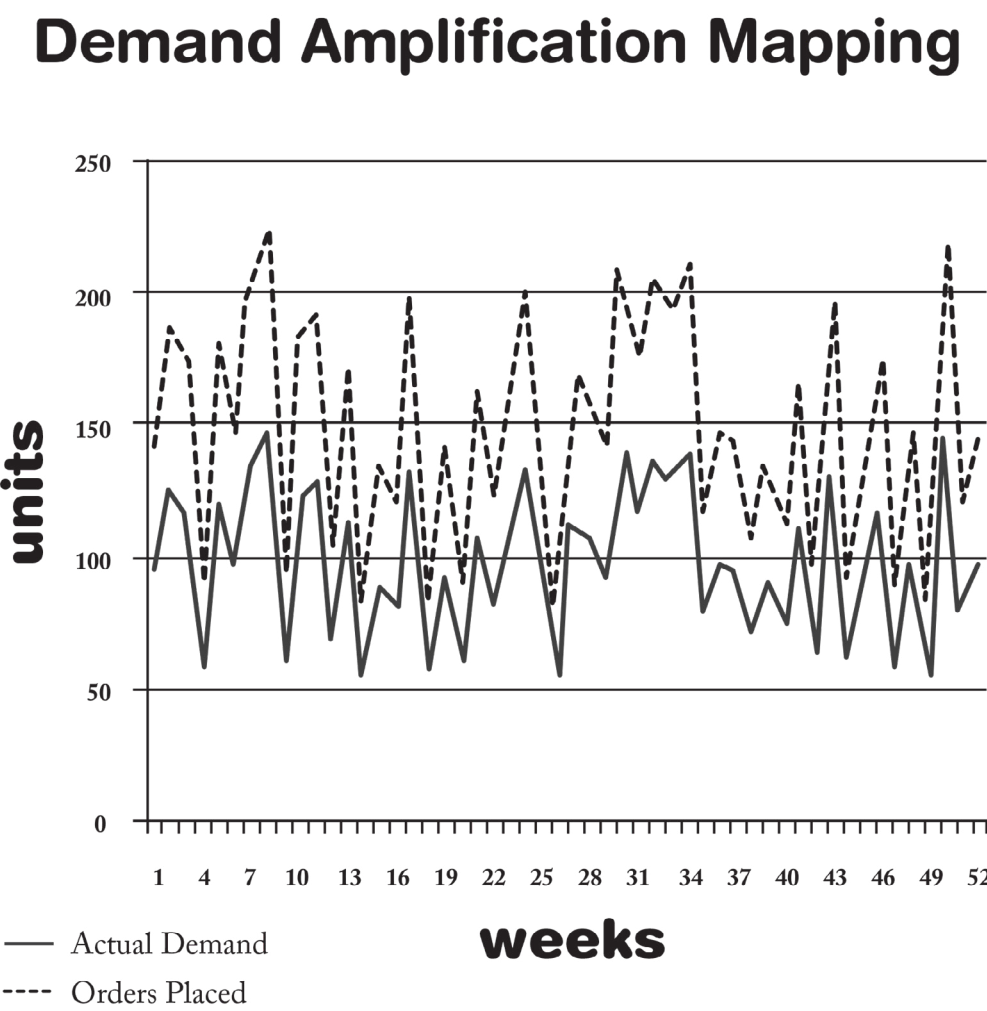




fig. 17

## Decision Point Analysis

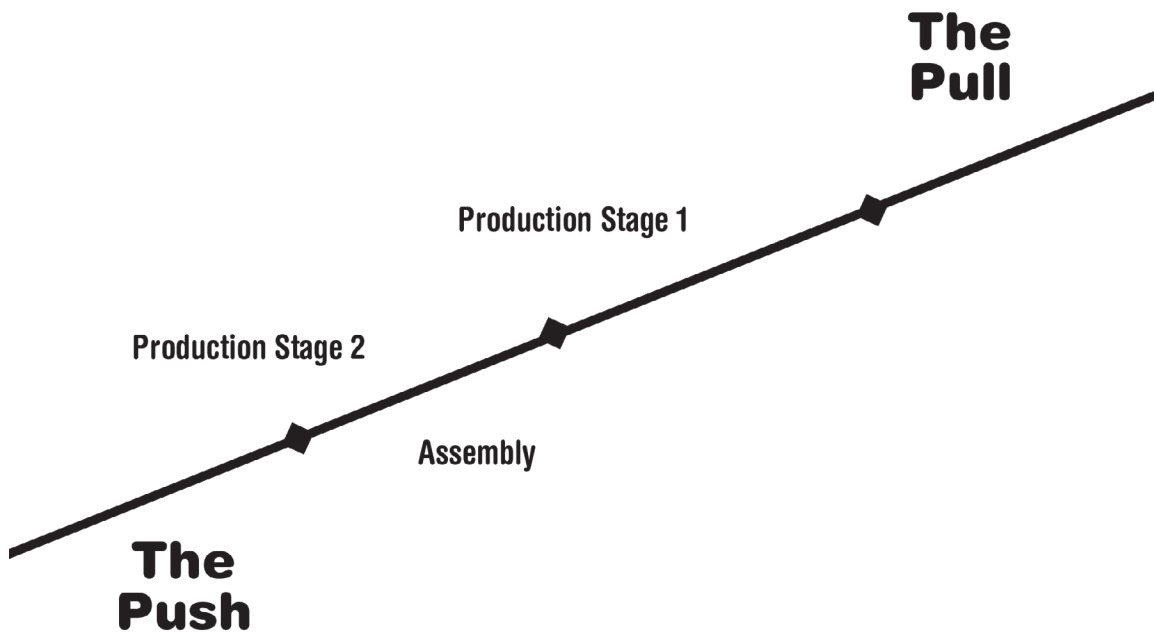


fig. 18

## Cost-Based Physical Structure Map

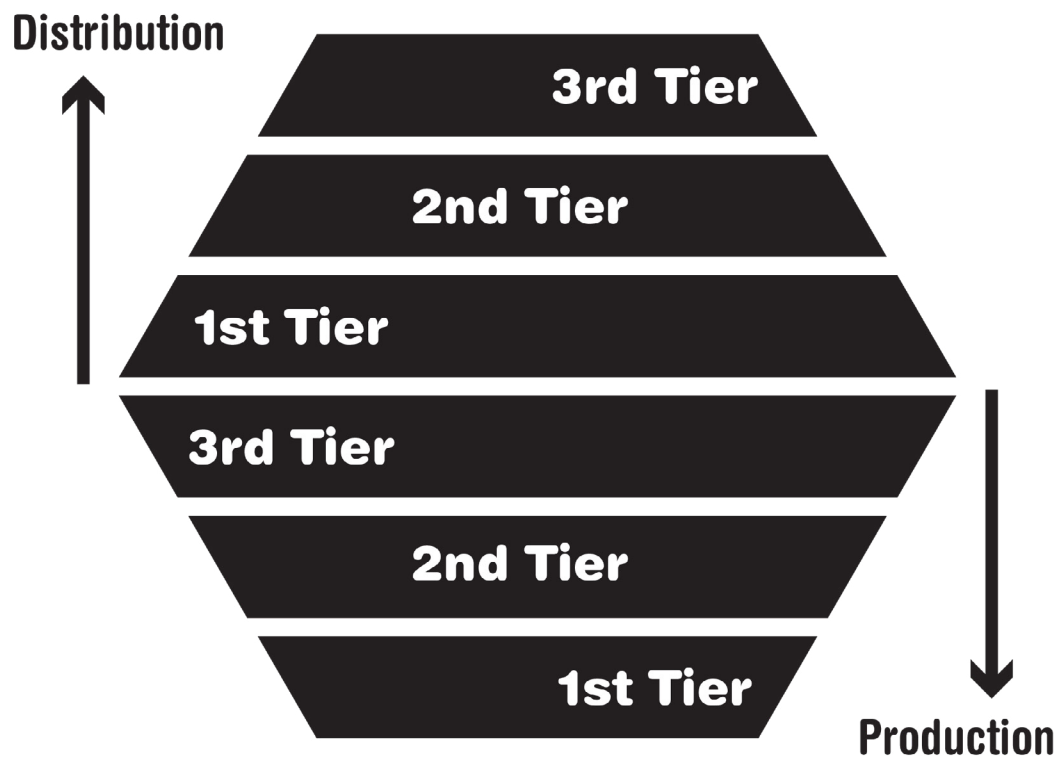


fig. 19

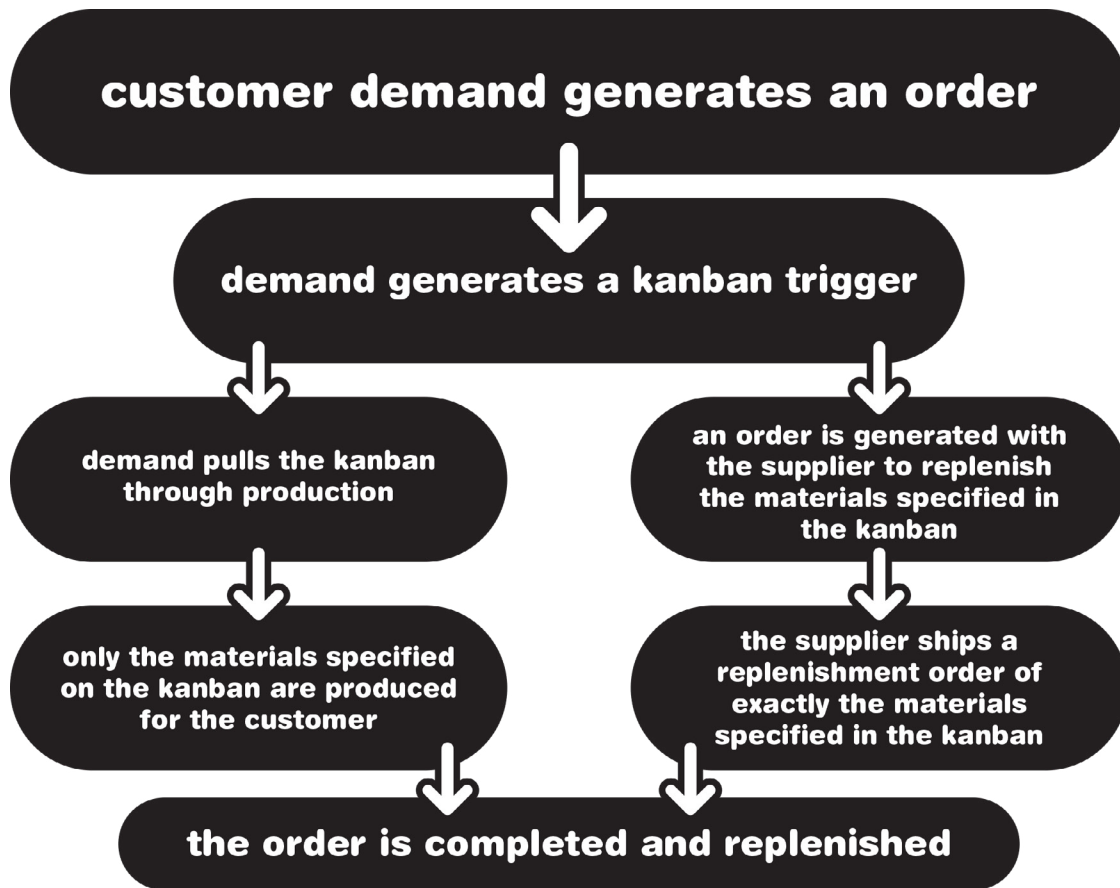


fig. 20

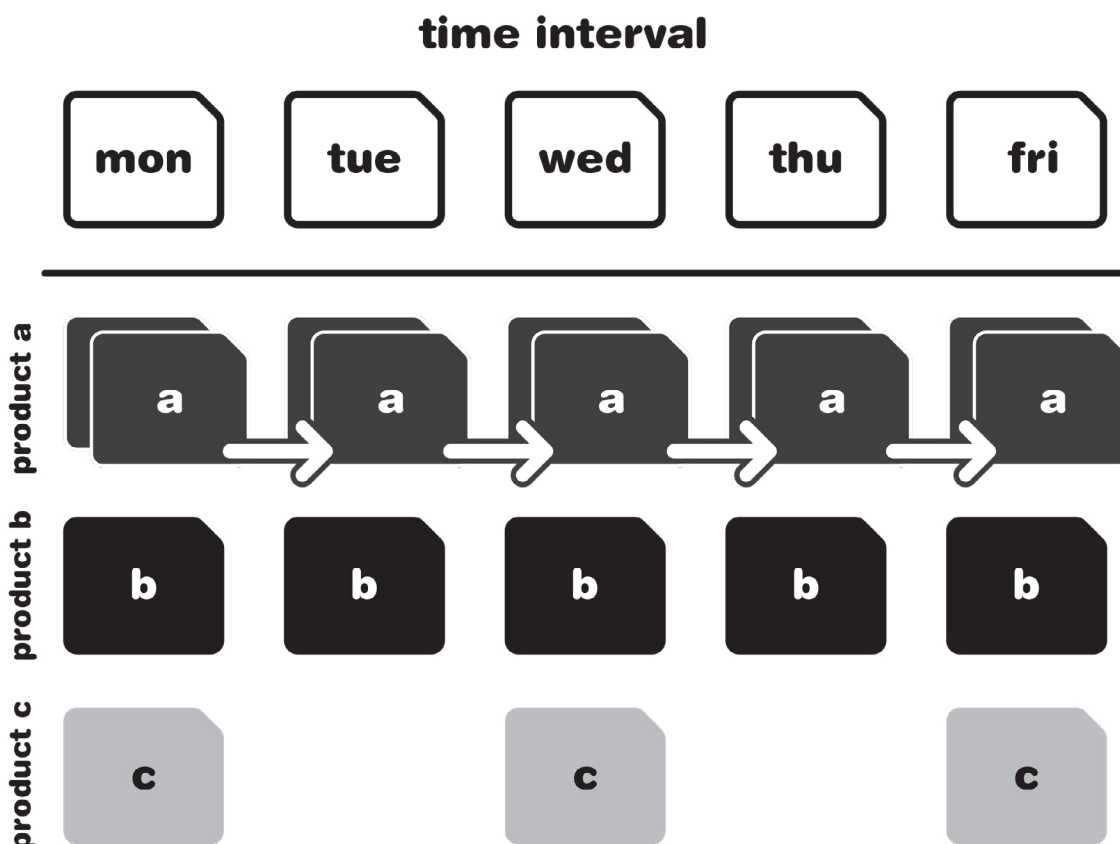


fig. 21

$$\mathbf{T} = \frac{\mathbf{T}_a}{\mathbf{D}}$$

fig. 22

|                    |            |
|--------------------|------------|
| <b>Gross Time</b>  | <b>480</b> |
| <b>Lunch</b>       | <b>-30</b> |
| <b>Breaks</b>      | <b>-30</b> |
| <b>Meetings</b>    | <b>-10</b> |
| <b>Inspections</b> | <b>-10</b> |
|                    | <b>400</b> |

fig. 23

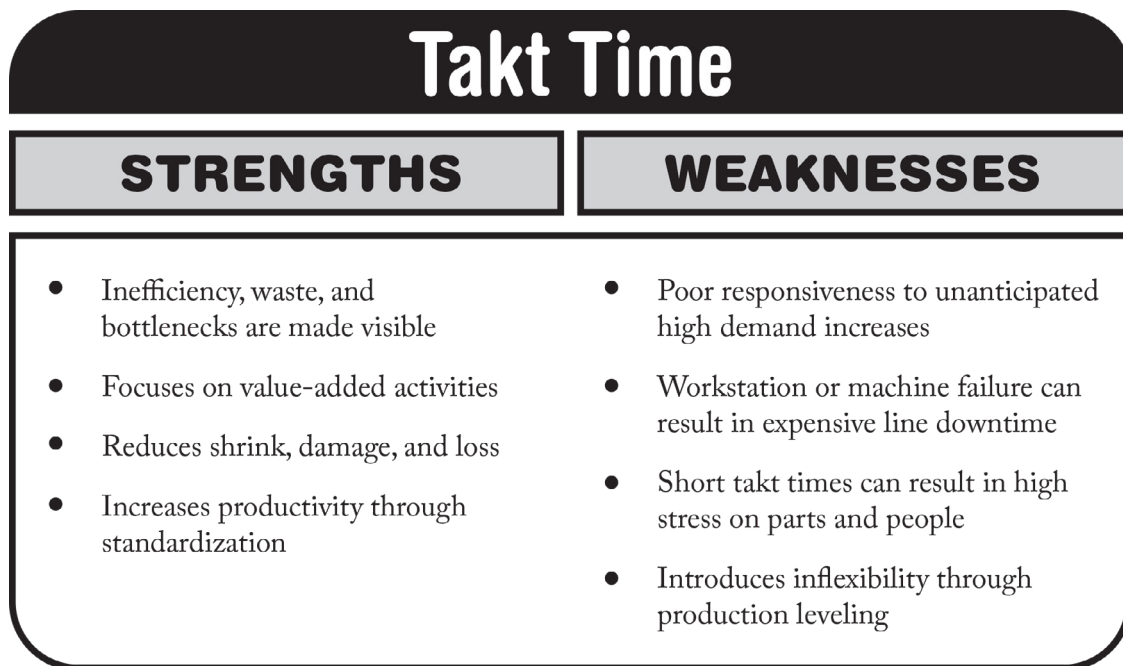


fig. 24

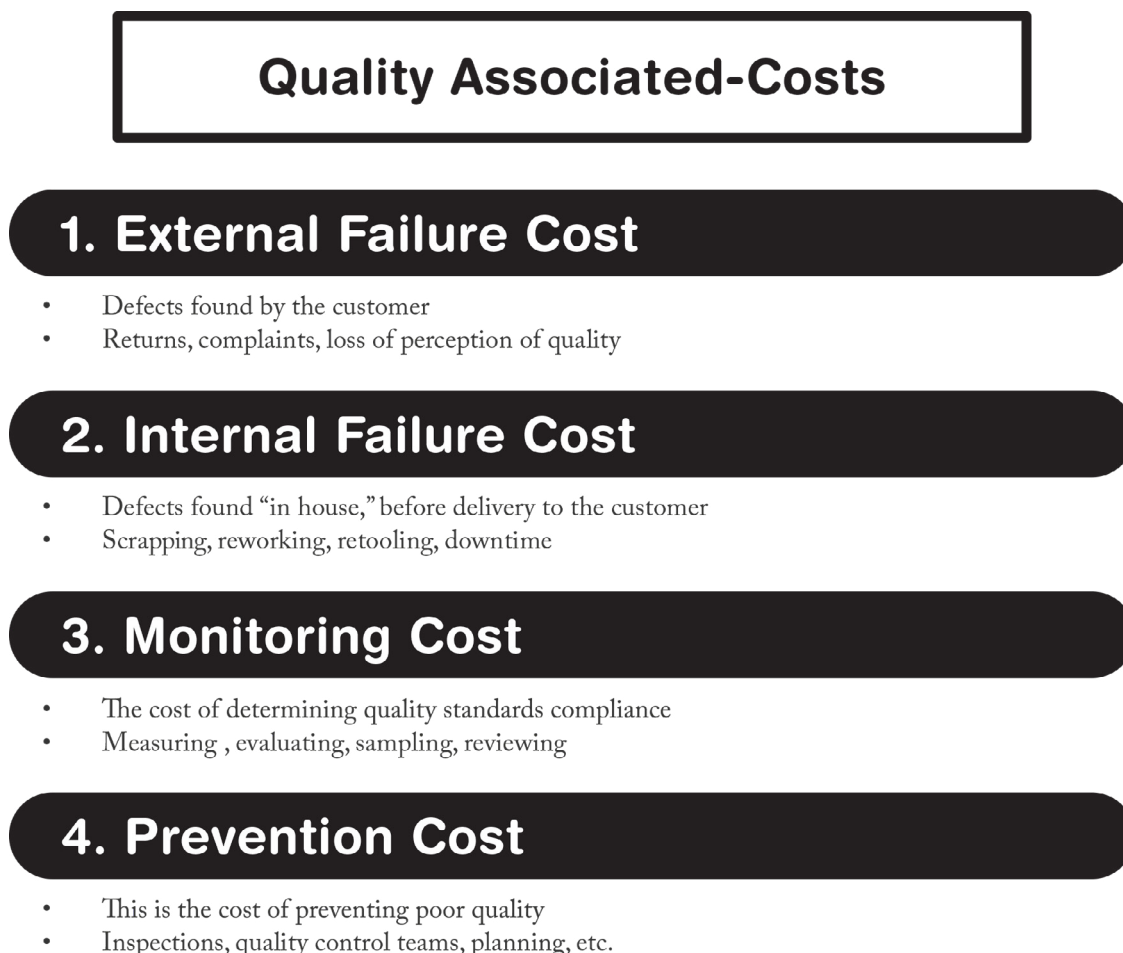


fig. 25

## Fixed Position Layout

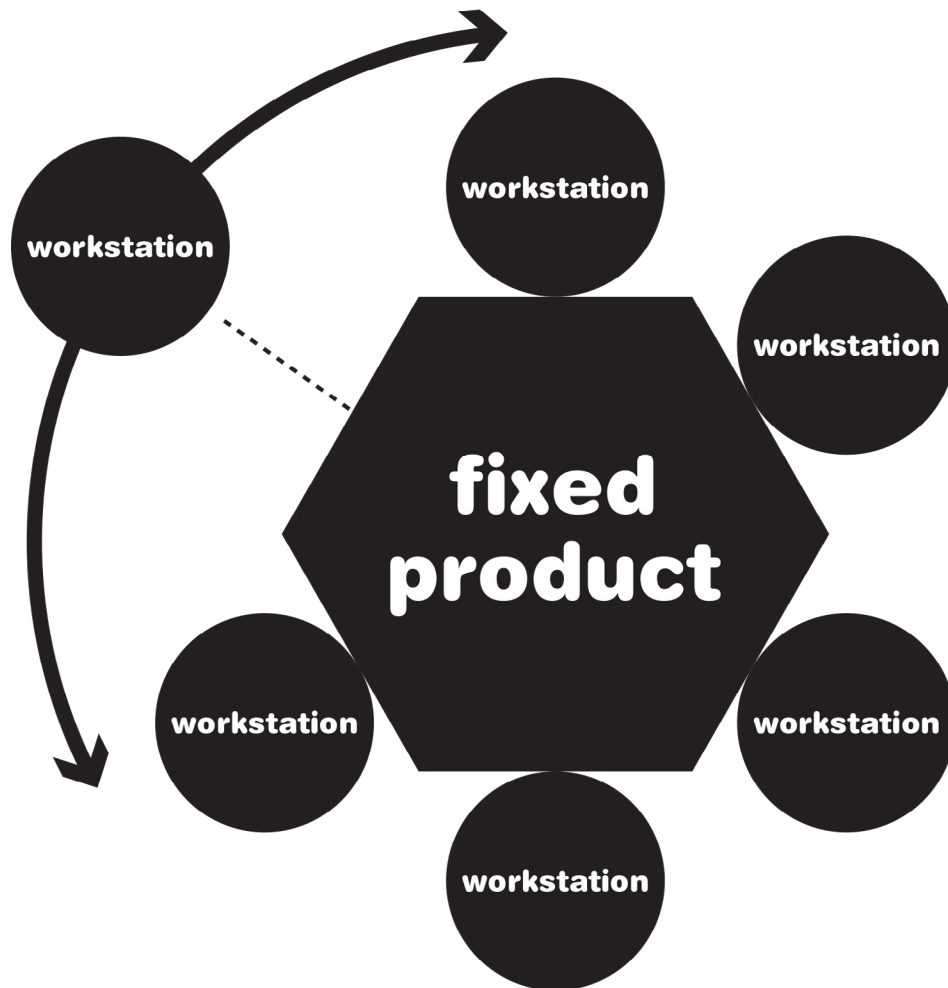


fig. 26

## Product Layout

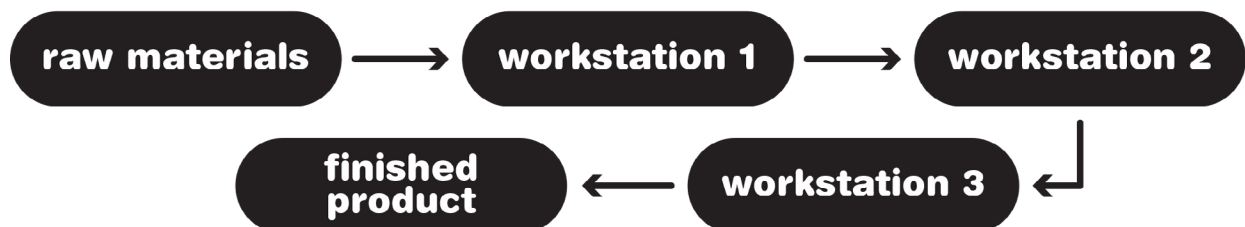


fig. 27

# Process Layout

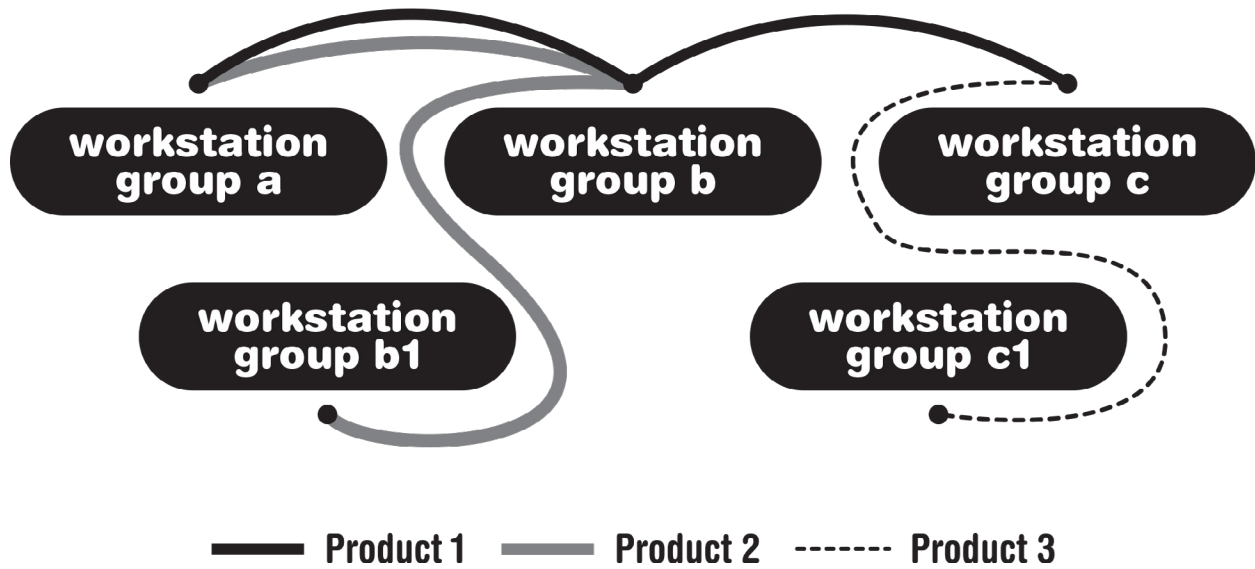


fig. 28

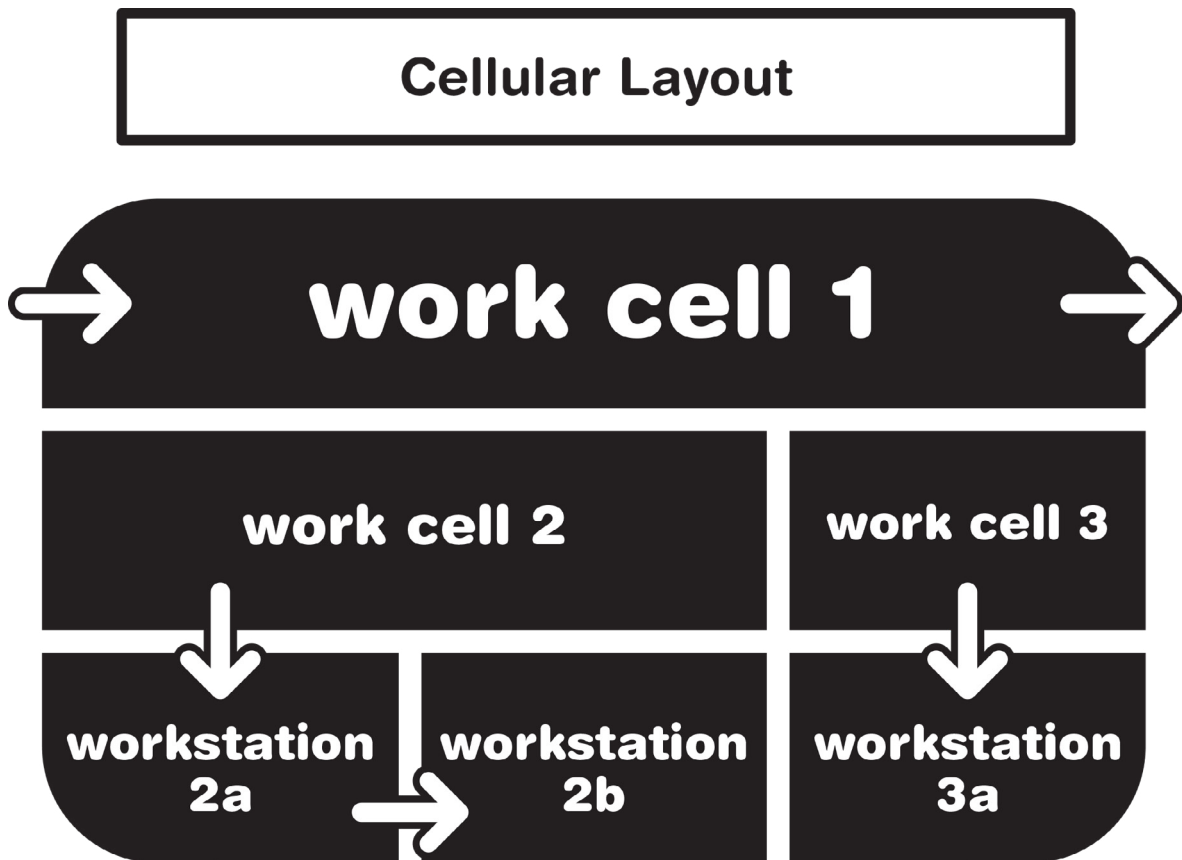


fig. 29

## Summary of Production Layouts

### 1. Fixed Position Layout

- Used for production of static products
- Airplanes, homes, installations

### 2. Product Layout

- Used for production of static products
- Airplanes, homes, installations

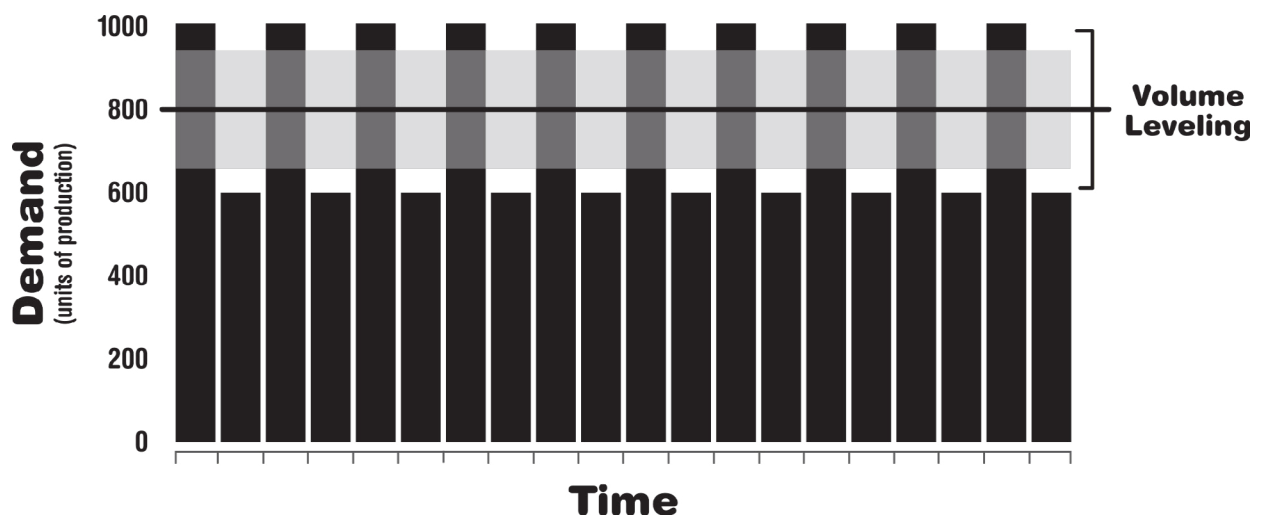
### 3. Process Layout

- Used for production of low-volume products with high differentiation
- Service industries, retail, studios

### 4. Cellular Layout

- Combines product and process layouts for efficiency
- Groups products into families for efficiency

fig. 30



## CHAPTER 3

### The Lean Toolkit

fig. 31

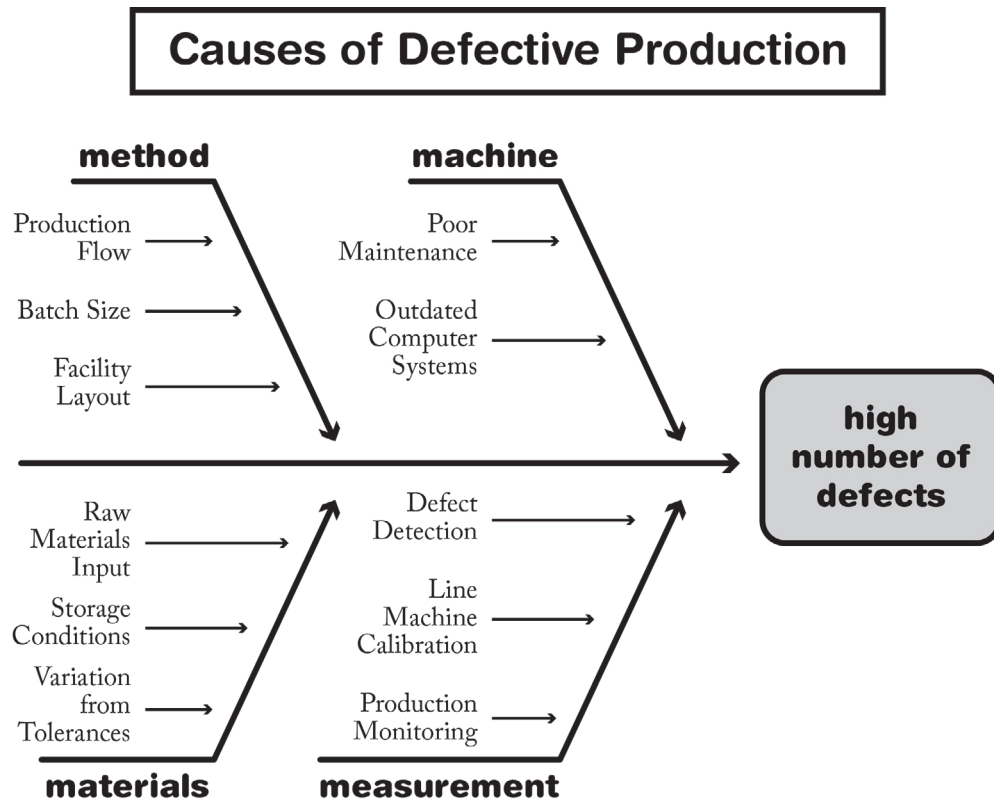


fig. 32

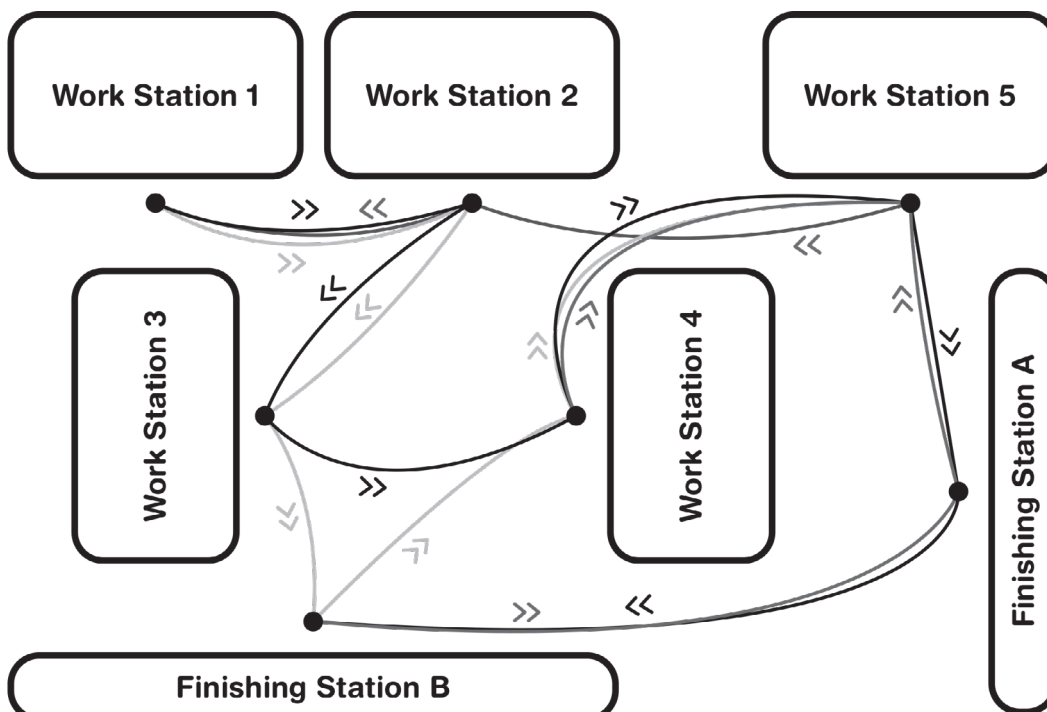




fig. 33

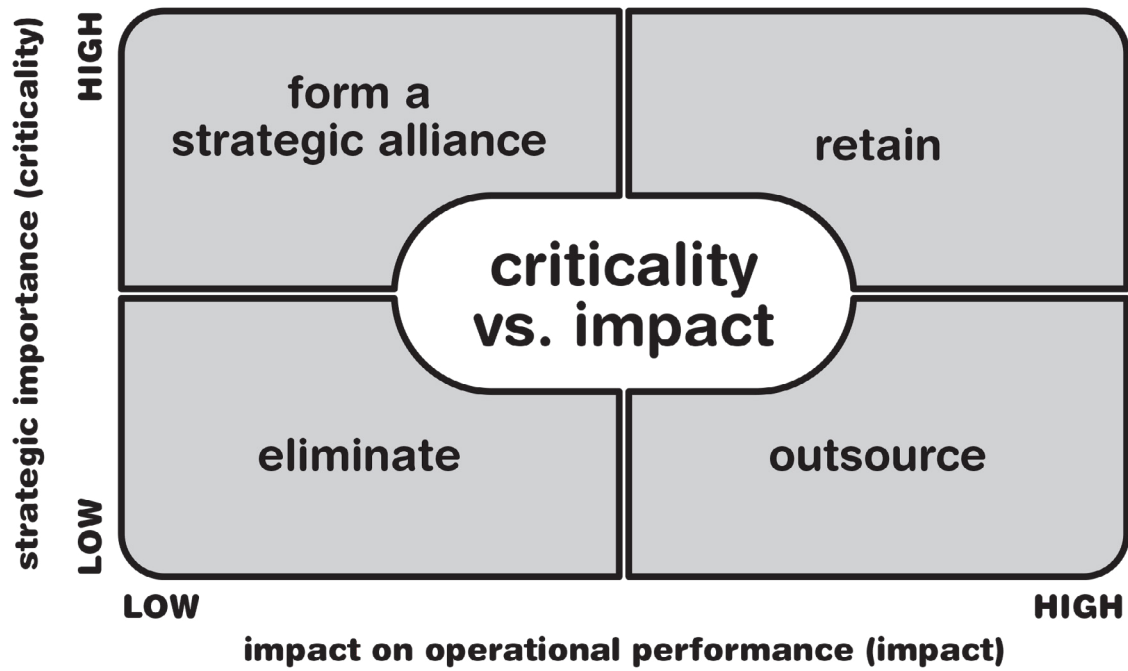
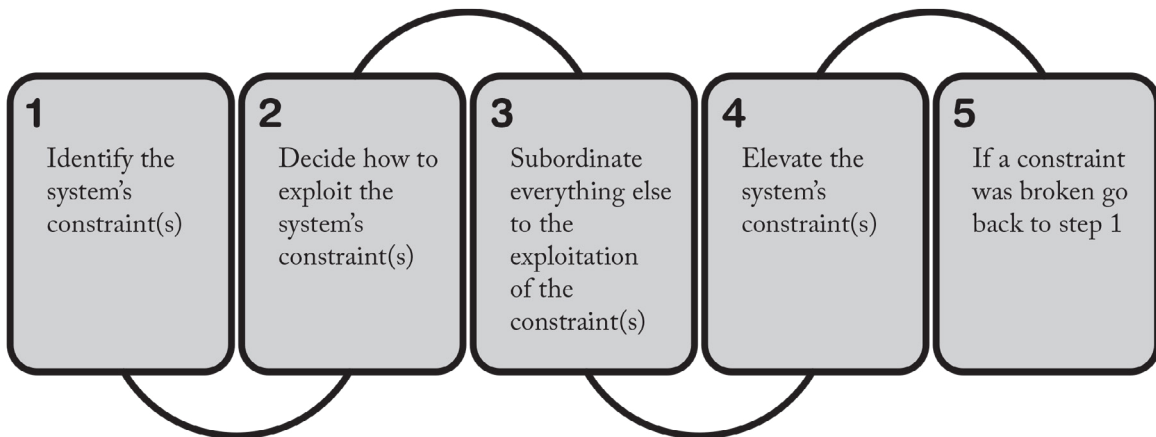


fig. 34

**There is always at least one constraint limiting a system**



## CHAPTER 4

### Implementation Considerations

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fig. 35

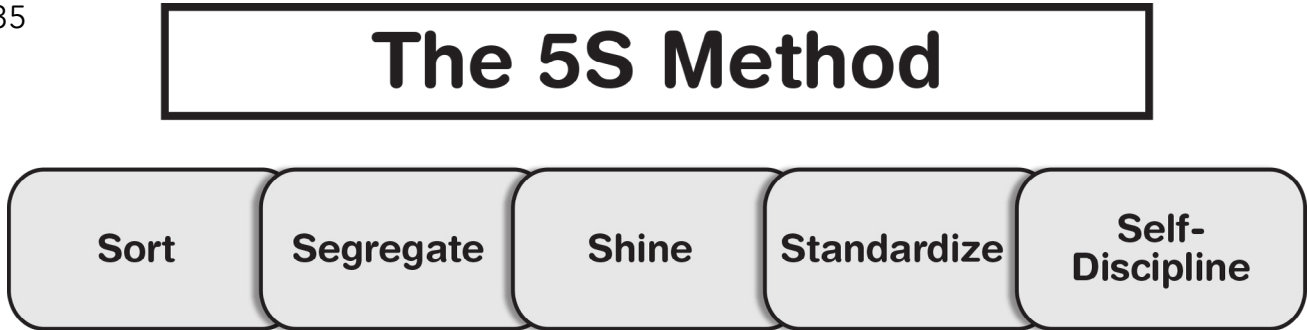
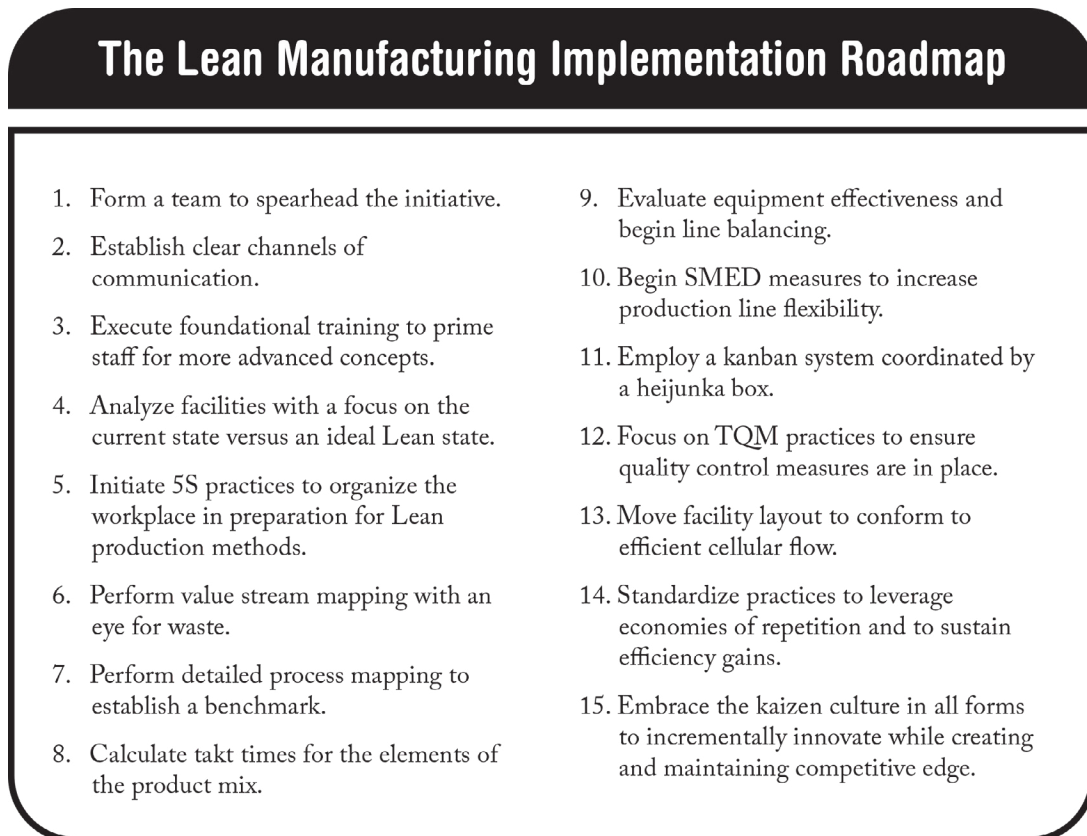


fig. 36



# APPENDIX

## Value Stream Mapping Sample

fig. 37

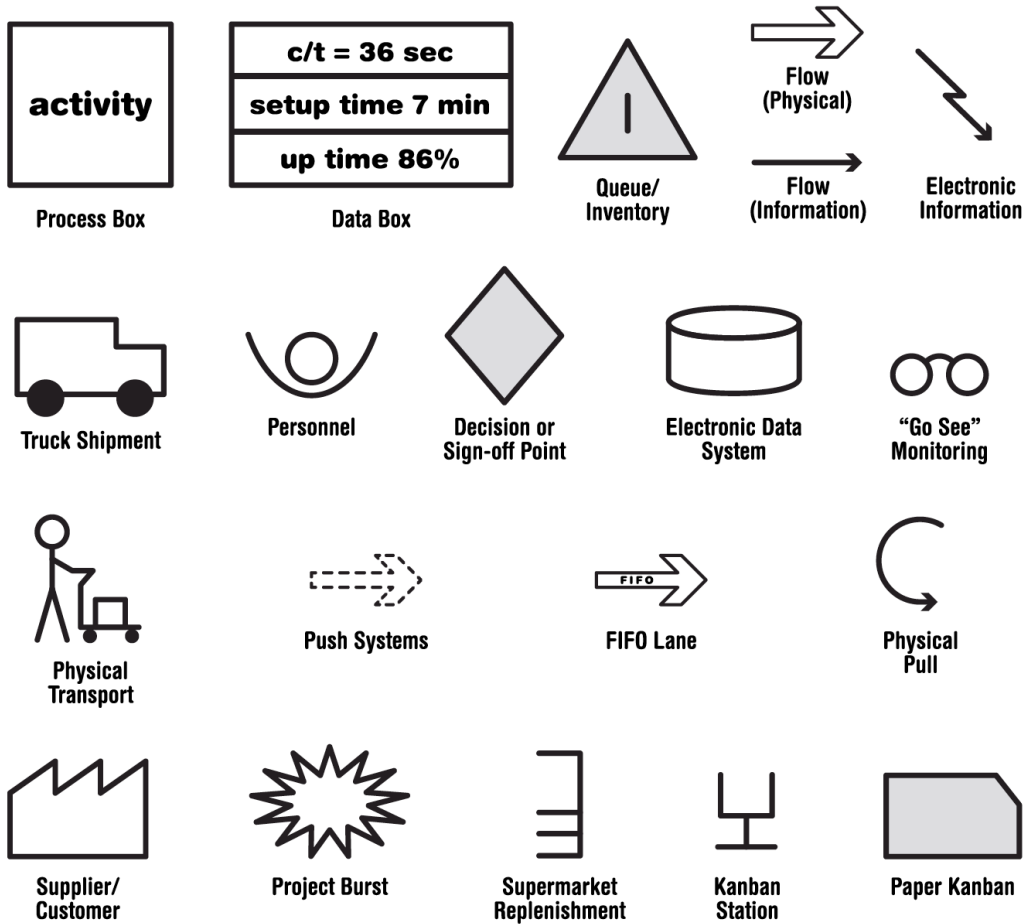


fig. 38

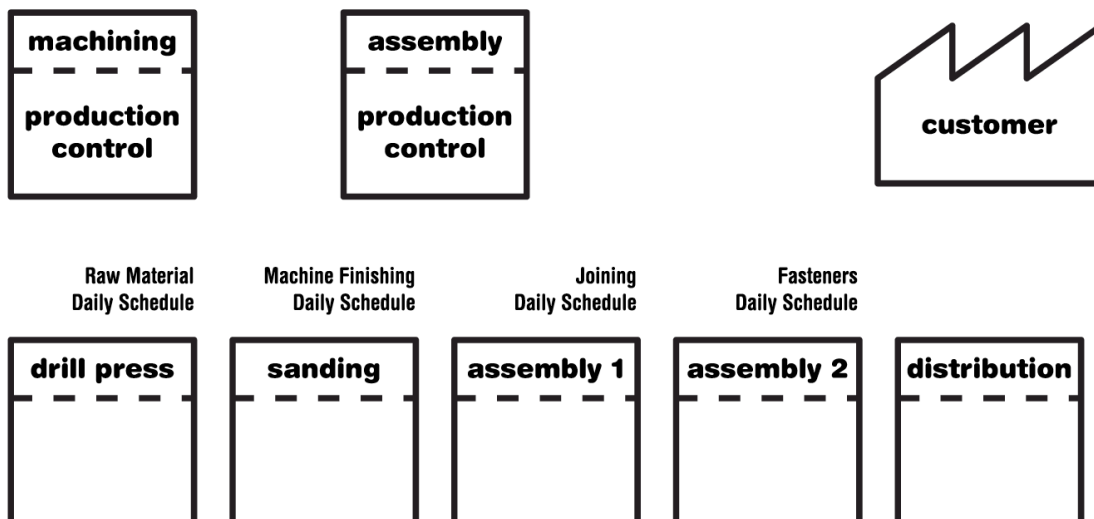


fig. 39

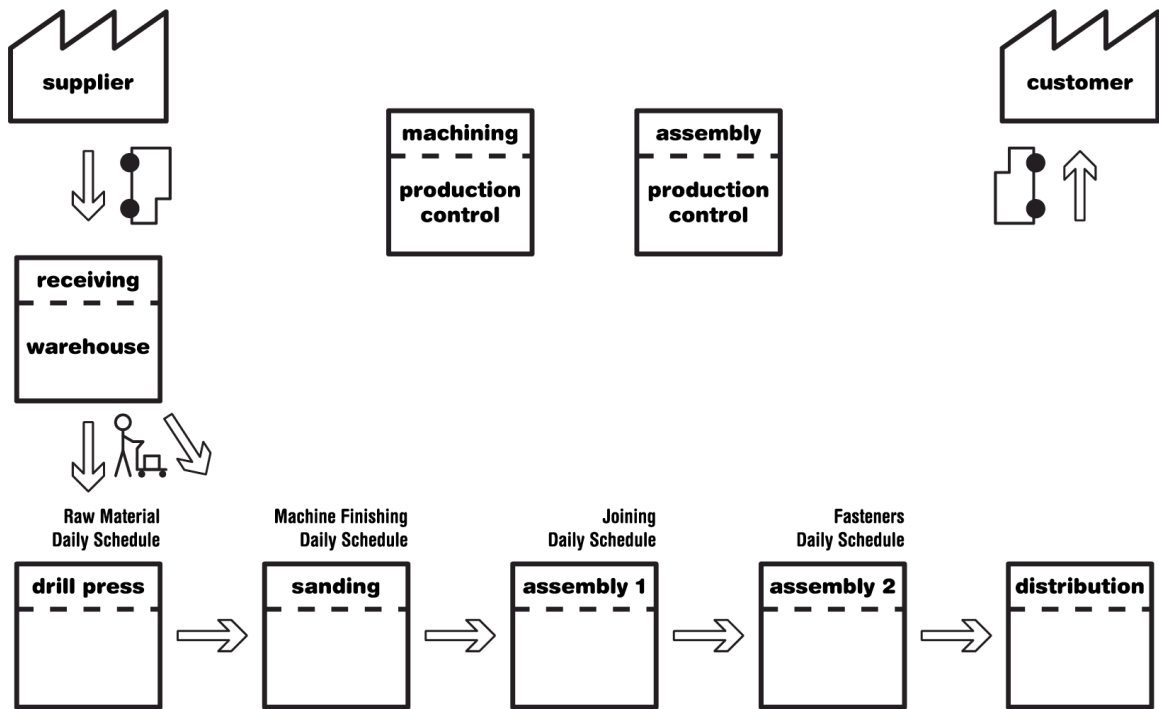


fig. 40

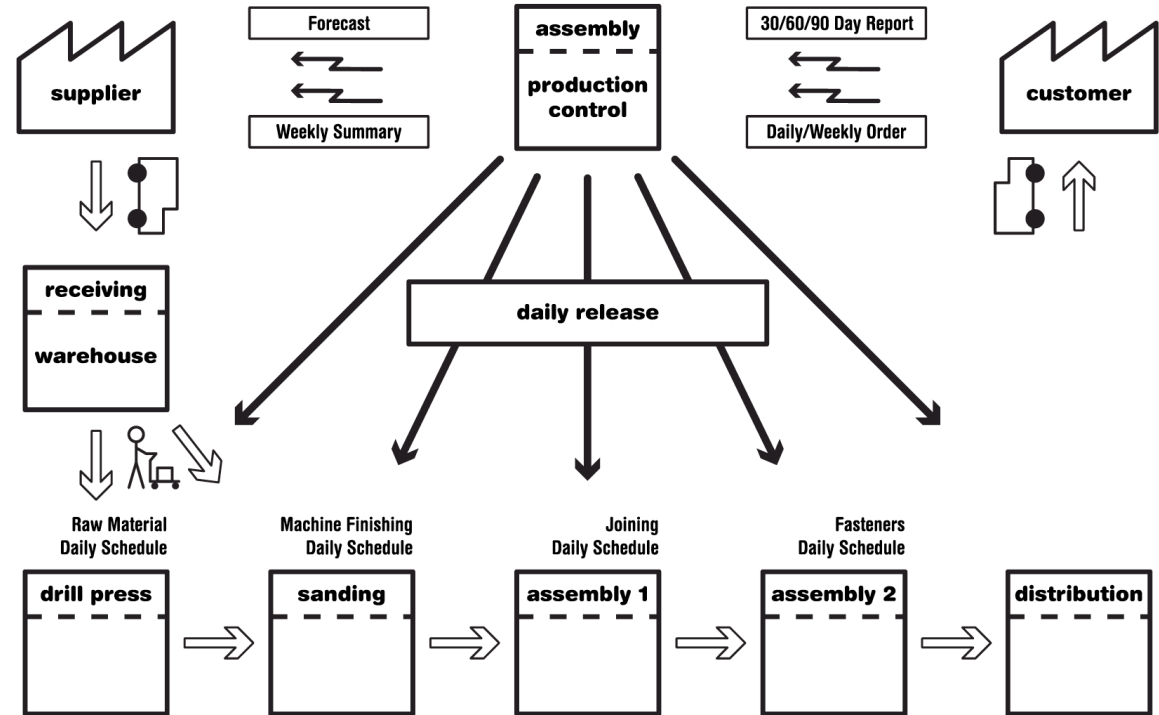
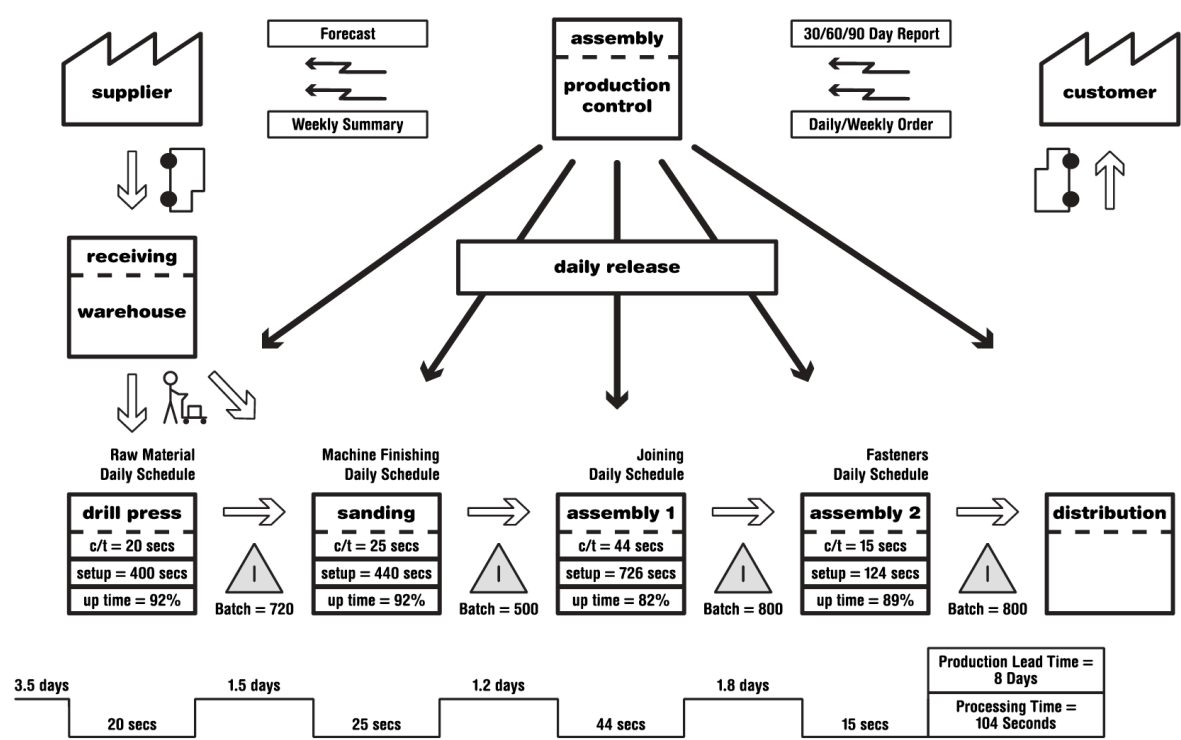


fig. 41



# GLOSSARY

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## 5M

the 5 M's of manufacturing. The 5 M's represent the primary categories of causal effects that should be considered when brainstorming potential causes for inclusion in a fishbone diagram. The 5 M's are as follows: machine, method, material, manpower, and measurement.

## 5S Method

a process-oriented program of workplace organization. The 5S method standardizes best practices for the efficient execution of day-to-day activities. The 5 S's are as follows: sort, segregate, shine, standardize, and self-discipline.

## 5W1H

a structured investigative method used to determine the root cause of an issue. The process uses a successive series of "why" questions to bring hidden causal effects to the surface.

## A3 Problem Solving Method

a practical application of the PDCA process improvement and problem solving method. Using a single piece of ISO A3-sized paper (11"x17"), the focus of problems is narrowed, and a structured investigative approach can be applied.

## Buffer Inventory

see Safety Stock.

## Bullwhip Effect

the concept that miscommunication amplifies disruption and variation throughout the supply chain and throughout an organization. When one department gets a garbled message, they are likely to distort it to the next department and so on until it reaches the final recipient, where the message is completely distorted.

## Cellular Facility Layout

a facility layout that aims for maximum flexibility and efficiency by combining aspects of the product-oriented facility layout and the process-oriented facility layout. Clusters of workstations are organized into "product families" and then designed to fit the process layout.

## Core Competency

a set of business operations at which a particular organization excels. A core competency is the foundational component of competitive edge.

## D.O.W.N.T.I.M.E.

an acronym used to help remember the eight sources of physical waste (muda): defective production, overprocessing, waiting, non-used employee talent, inventory, motion, and excessive production.

## Decision Point Analysis

a tool primarily used by organizations utilizing a "T" configuration production scheme. This mapping tool identifies the point at which pull demand (actual customer demand) gives way to demand that has been forecasted (artificial demand).

## Outsource Decision Matrix

a tool used to identify processes, activities, and tasks that are candidates for outsourcing through the comparison of criticality and impact.

## Demand Amplification Mapping

also known as Forrester Effect Mapping, demand amplification mapping is a visual tool used to identify the distortion that occurs between different supply chain entities within the value stream.

## Economies of Repetition

the concept that the repetition of specific activities and processes increases efficiency over time.

## Economies of Scale

the microeconomic concept that as the size and output of a manufacturing operation increases, costs can be spread out over more units, thereby reducing the cost to produce each unit. Economies of scale is a large cost reduction driver of push production and large batch manufacturing.

## E-Kanban

the electronic integration of a kanban system into an organization's ERP (enterprise resource planning) software. E-kanban systems generally cost more to implement, but have unprecedented levels of visibility and do not suffer from the disruptions of lost, illegible, or damaged kanban cards.

## External Setup Operations

line changeover setup operations that can be performed while the production machine is still running. This is much more desirable than changeovers that require machine shutdown (internal setup operations) because the production line can continue to move while adjustments are taking place.

## Fixed Position Facility Layout

a facility layout method best employed when the product in question is so large or heavy that workstations move around the product rather than the product moving around the workstation. Forrester Effect Mapping—see Demand Amplification Mapping.

## Heijunka Box

a visual scheduling tool that uses a grid-like construction to organize various kanban control cards by their various stages within the production process. An essential tool to promote even production flow, heijunka boxes are a critical scheduling component of kanban implementation.

## Internal Setup Operations

line changeover operations that require that the production machine be shut down, thus causing stoppage on the production line. The Single Minute Exchange of Die method seeks to reduce this disruption by converting internal setup operations into external ones.

## Inventory

the total on-hand store of goods, materials, and supplies. For production operations, production inventory is broken into three stages: raw materials, work in progress, and finished goods.

## **Ishikawa Diagrams**

cause-and-effect diagrams that are used to investigate and determine the root causes of a specific effect impacting a process at hand. Also known as fishbone diagrams.

## **IVAT Analysis**

see Production Variety Funnel.

## **Just-in-Time**

a method of cost reduction through the elimination of carrying inventory. Just-in-Time protocols ensure that only the amount of materials needed for production are transported, and that they arrive exactly when needed. On the finished goods side of production, JIT methods produce small batches that are a close match for customer demand, and are scheduled and produced in such a way that the manufacturer never has to carry inventory.

## **Kaizen**

the implementation of a culture of constant improvement, and a central theme of the Lean philosophy and business model. Kaizen is built on the premise that continual, incremental change causes the least amount of disruption, and that change can build upon other, previous changes to create innovation and competitive edge. Kaizen values the input of employees at all levels of the organization, recognizing that the spark of innovation can come from anywhere.

## **Kanban**

a flow-oriented method of material and goods coordination and replenishment. Based on the shelf-stocking methods of supermarkets, kanban operations simultaneously move products through the value stream while replenishing the materials that were consumed through production.

## **Lag Measures**

metrics and insights that can be gathered after the fact. Lag measures represent the feedback portion of a closed-loop system.

## **Lean Six Sigma**

a hybrid business management system that includes components from both Lean Manufacturing and Six Sigma Quality. Lean Six Sigma offers a total package of production optimization, quality control, waste reduction, and competitive edge.

## **Machine (5M)**

a causal category for the construction of fishbone diagrams. The machine category encompasses any equipment related to the process at hand. This includes computer systems and production tools primarily, but also extends to all tools that may be a part of the production process.

## **Manpower (5M)**

a causal category for the construction of fishbone diagrams. The manpower category encompasses any people who might have a causal impact on the process at hand.

## **Material (5M)**

a causal category for the construction of fishbone diagrams. The material category encompasses any and all materials that are involved in the production cycle and that may have a causal impact on the process at hand.

## **Measurement (5M)**

a causal category for the construction of fishbone diagrams. The measurement category encompasses any and all measurements and data collection that may occur in regard to the process at hand. This includes the accuracy of observations, thoroughness of investigations, and the calibration of data-gathering equipment.

## **Method (5M)**

a causal category for the construction of fishbone diagrams. The method category encompasses the total sum of protocols, process design, and methodology employed for the execution of the process at hand.

## **Muda**

one of the three overall sources of waste, muda represents physical waste events. All physical waste events can be traced back to the D.O.W.N.T.I.M.E. eight sources of waste.

## **Mura**

one of the three overall sources of waste, mura represents waste in the form of unevenness of production, or unequal production loading.

## **Muri**

one of the three overall sources of waste, muri represents waste in the form of overburden or a failure to understand production capacity.

## **Net Available Time to Work**

a component of takt time calculation. The total amount of time that is available for production activities, less breaks and other nonproduction time set aside for business activities.

## **Non-Value-Added**

activities that do not produce value that can be passed along to the customer. Non-value-added events are considered waste, and the Lean philosophy relentlessly works to not only differentiate value-added from non-value-added activities, but to reduce the impact that non-value-added activities (waste events) have on business processes.

## **Outsourcing**

the process of assigning business activities to a third party vendor or business with the intent of leveraging the economies of core competency or cost reduction.

## **PDCA**

a problem-solving and process-improvement process that focuses on creating actionable feedback. Plan, Do, Check, Adjust (or Act), also known as the Deming Cycle, has a wide variety of applications not only across the Lean business model but across a variety of industries.

## **Physical Structure Mapping**

an overview of an entire supply chain that is generated based on its physical structure. The physical structure map can be constructed either by visualizing cost centers or through volume-based mapping.

## **Poka-Yoke**

intentional constraints that are introduced into operations to reduce defective production due to human error. These “foolproofing” measures turn normal operations activities into processes, improving teachability and leveraging the economies of repetition.

## **Process Activity Mapping**

a narrower look at the components of a value stream. This tool dissects and maps individual processes as opposed to the entire value stream.

## **Process Facility Layout**

a facility layout that favors products with low volumes and high levels of differentiation. Under this facility layout protocol, workstations and resources are grouped based on the various paths that produce the product variants.

## **Product Facility Layout**

a facility layout that is ideal for mass production—high volumes of products with little or no differentiation. This facility layout is most closely associated with traditional manufacturing, the push production system, and the economies of scale.



## **Production Leveling**

the process of reducing the creation of waste events due to unevenness of production flow. Production leveling can be performed on the production side of the equation as well as the demand side to introduce evenness into production.

## **Production Variety Funnel**

also known as an IVAT analysis, the production variety funnel analysis identifies which set of manufacturing models the production of a particular product conforms to. Once the mode of production has been identified, specific and known traits and protocols can be applied to the production of goods.

## **Pull Production System**

the opposite of the push production system, the pull production system focuses on customer demand. As demand is generated, materials and goods are “pulled” into the production cycle, and in this way production matches demand as demand changes. The pull production system, when working in tandem with many of Lean’s flexible manufacturing methods, creates a responsive production process that matches demand and does not carry excess inventory or generate waste through the production of large batches.

## **Push Production System**

the traditional approach to manufacturing whereby artificial demand is “pushed” through the production cycle. Large batches of goods are stored in anticipation of forecasted sales. Leveraging the economies of scale, costs are spread out over a high number of units, bringing the unit cost down and picking up the slack of this high-waste system.

## **Quality Filter Mapping**

a visual tool that identifies areas where quality issues exist within a value stream. With the deployment of this method, three sources of insufficient quality can be identified: product defects, service defects, and internal scrap.

## **Raw Materials**

the basic materials from which finished goods are made. This unfinished material is generally assumed to be homogeneous and comprises the raw materials portion of production inventory (raw materials, work in progress, finished goods).

## **Safety Stock**

a buffer to insulate inventory levels from fluctuations in demand. Safety stock is a characteristic of the push production system, where artificial demand is “pushed” through the production process. Conversely, the pull production system’s flexibility and focus on actual demand eliminates the need for, and cost of carrying, safety stock.

## **Segregate (5S)**

a component of the 5S method, segregation is the next logical step after sorting. Once materials and tools have been examined and determined to be relevant to the process at hand, they are organized (or segregated) to ensure that they are available in an efficient manner.

## **Self-Discipline (5S)**

a component of the 5S method, self-discipline (also known as “sustain”) is the structured and conscious effort to maintain the rigors of the 5S method and sustain the gains afforded by its implementation.

## **Shine (5S)**

a component of the 5S method, shine reflects all of the positive aspects of maintaining a clean and orderly workplace. From employee confidence and respect to reduced safety hazards, a clean workplace is an efficient one.

## **Single Minute Exchange of Die (SMED)**

a flexibility and cost-cutting program that strives to reduce the line changeover time to a single digit number of minutes. This radically increases the flexibility and responsiveness of production and reduces levels of waste. Mastering SMED within an organization is a critical component of a highly developed and flexible pull production system.

## **Six Sigma Quality**

a process-improvement and quality-focused business management method that uses statistical tools to improve productivity and quality throughout. Many of the tools available within the Six Sigma system can be used in tandem with the Lean philosophy and toolkit, producing the hybrid business improvement method Lean Six Sigma.

## **Small Lot Production**

a feature of the pull production system that focuses on waste reduction and flexibility through the production of batches that meet demand instead of large batches that are based on artificial demand and are “pushed” through production.

## **Sort (5S)**

a part of the 5S framework, the concept of a sorted workspace determines the most expedient and useful places for objects, tools, materials, and goods.

## **Spaghetti Plot**

a visual map of data that can be expressed as flows. Also known as workflow charts, spaghetti plots are used to track the movements of people and goods to determine more efficient layouts.

## **Standardization (5S)**

a part of the 5S framework, standardization seeks to transform activities into processes so that they can benefit from the economies of repetition.

## **Supply Chain Responsiveness Matrix**

a visual tool that analyzes an organization’s lead time and inventory levels. The resulting graph highlights areas where slow-moving stock is concentrated.

## **Takt Time**

a measure of unit production time relevant to the rate of customer demand. While the product of a takt time is expressed as a certain number of parts per period, this is a measure of flow and may not reflect the actual duration of production for each unit.

## **Theory of Constraints (TOC)**

a systems improvement model that is built on the basic assumption that every system is subject to at least one constraint that creates a bottleneck. Once this constraint has been broken, the system will become more efficient, but is now subject to another, new limiting factor. This system is helpful for determining areas of inefficiency within operations, and assessing the best methods to effect change.

## **Total Quality Management (TQM)**

a unifying principle that underscores the interdependent relationship between the voice of the customer, the tools and processes used to manufacture goods, and the manner in which demand “pulls” goods through production.

## **Toyota Production System**

the set of principles, methods, and tools established by the Japanese vehicle manufacturer Toyota. The strides made by the Toyota company revolutionized and supercharged the Japanese economy, and the effective methods employed by Toyota have evolved into the versatile Lean Manufacturing system that we know today.



**Tunnel Vision**

a singular focus on one goal at the expense of visibility of others or the whole picture.

**Value Stream**

the total sum of effort, operations, processes, and production that contributes to the creation of value for a customer. Value stream doesn't begin and end with the manufacturing organization. It begins with the customer and works backward through the supply chain, all the way upstream to the point of origin.

**Value Stream Mapping**

a Lean toolkit that is used to assess the current state of all activities and processes associated with production operations. The application of value stream mapping is designed to highlight areas where improvement is possible, and to differentiate value-added activities from waste, all while establishing a benchmark against which all improvement activities can be measured.

**Value-Added**

activity that incurs costs that can be passed on to the customer (creates value). The Lean method's focus on the Voice of the Customer is a core driver of the need to differentiate value-added and non-value-added activities. Through various improvement methods, operations are trimmed of non-value-added activities (waste) and streamlined to only the necessary value-added processes.

**Waste**

non-value-added activity. Waste incurs cost but does not produce value, so these costs cannot be passed on to the customer. Waste is represented within the Lean manufacturing system as falling under the categories of physical waste, unevenness of production, or overburden of production. In all aspects of Lean, the elimination of waste is a focal point of improvement activities.