

LEAN SIX SIGMA IMPROVE PHASE

"If you torture the data long enough, it will confess." - Ronald H. Coase



COURSE CONTENT

Coverage:

- ANALYZE PHASE TOOLS
 - Regression techniques - Simple linear regression
 - OFAT experimentas
 - LEAN concepts

Introduction to Predictive Analysis



Predictive analytics is the use of data, statistical algorithms and machine learning techniques to identify the likelihood of future outcomes based on historical data. The goal is to go beyond knowing what has happened to providing a best assessment of what will happen in the future.

With in the list of Predictive Analytics tools we will go in detail and understand about Regression analysis

Fundamental question...

Can we predict the Outcome Metric (Dependant Metric (or) Response Metric) by analyzing the impact or relationship that one or many Predictor Metric (Independent Metric (or) covariates) have on this outcome?

Answer to this question is **YES**

This takes us to one of the fundamental equations of six sigma

$$Y = f(x_1, x_2, x_3, x_4, \dots, x_n)$$

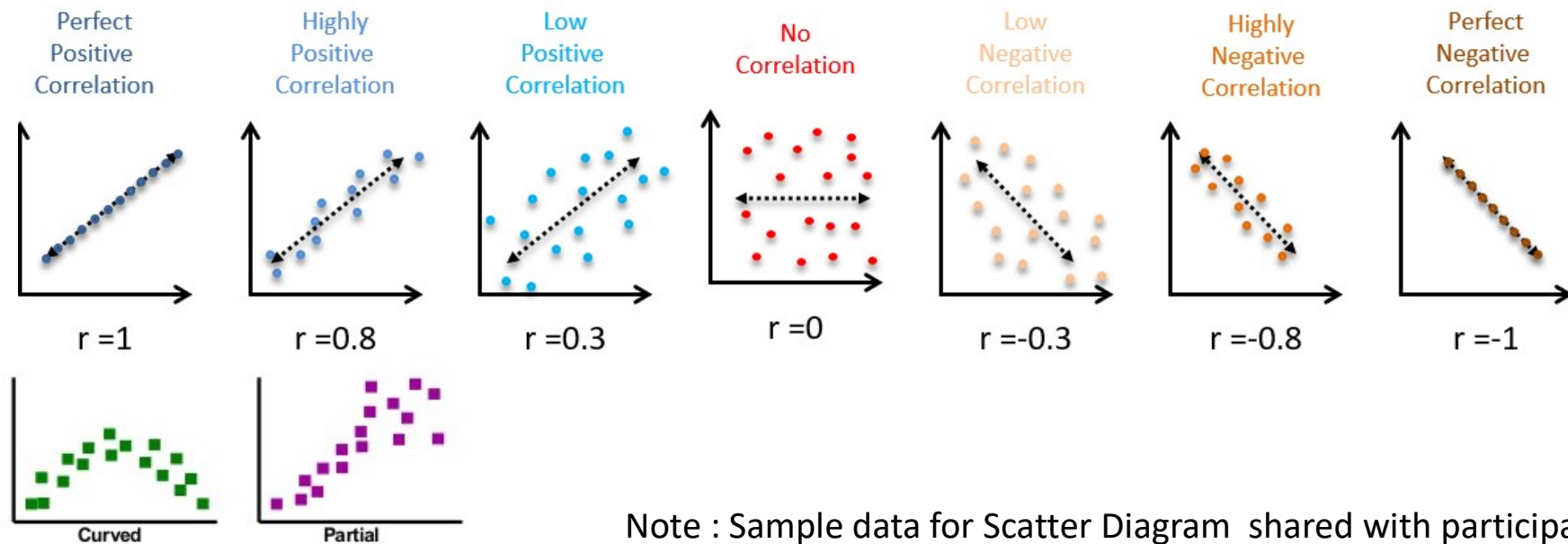
What do we understand from this equation...

We can predict what will be the value of if we can control Xs at a given level

Correlation

Correlation is a statistical technique that can show whether and how strongly pairs of variables are related. The strength of correlation is statistically represented “correlation coefficient” and graphically represented by “Scatter Diagram”

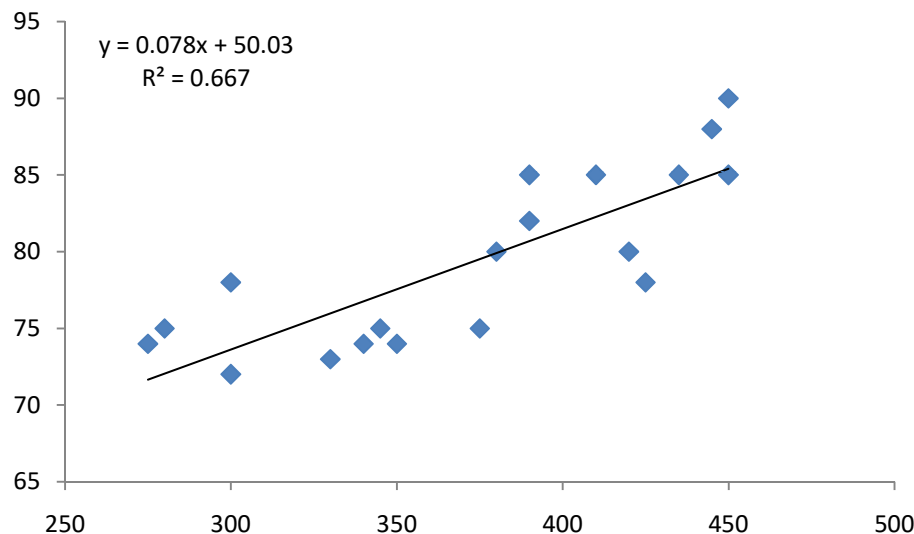
Scatter Plots & Correlation Examples



Note : Sample data for Scatter Diagram shared with participants

Simple Linear regression

Simple linear regression is a regression model that estimates the relationship between one independent variable and one dependent variable using a straight line



The line that get fitted here is called regression line

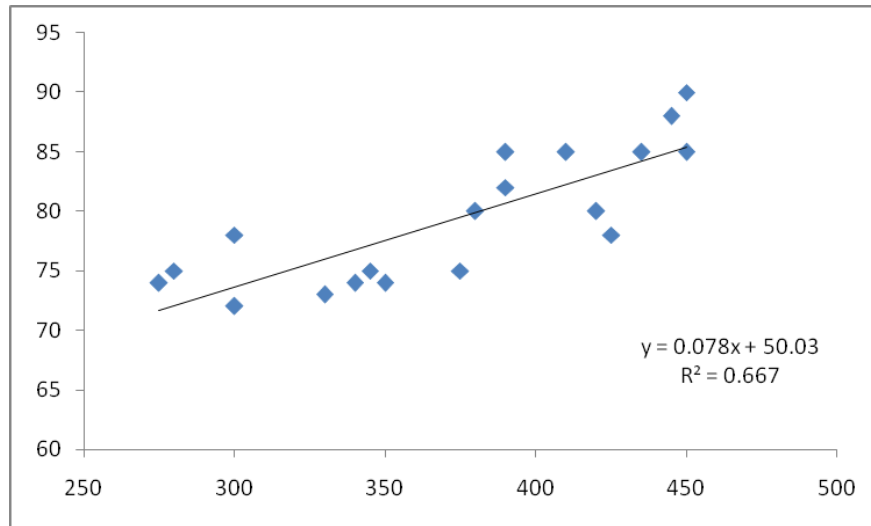
This line is fitted using least square method

Least squared method is nothing but to minimize the error between estimated value and actual value

Regression equation $Y = mX + C$

Lets understand how do we achieve this

Simple Linear regression



SLR

$$\text{\$ Value} = 50.03 + 0.0786 \text{ T (d)}$$

$$100 = 50.03 + 0.0786$$

$$\text{T (d)} = (100 - 50.03) / 0.0786$$

$$\text{T(d)} = 636$$

Regression Analysis: \$ Value Sold Per Day versus Tenure in days

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	376.83	376.83	34.15	0.000
Tenure in days	1	376.83	376.83	34.15	0.000
Error	17	187.59	11.03		
Lack-of-Fit	14	152.59	10.90	0.93	0.607
Pure Error	3	35.00	11.67		
Total	18	564.42			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
3.32185	66.76%	64.81%	58.42%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	50.03	5.08	9.85	0.000	
Tenure in days	0.0786	0.0135	5.84	0.000	1.00

Regression Equation

$$\text{\$ Value Sold Per Day} = 50.03 + 0.0786 \text{ Tenure in days}$$

Residual Plots for \$ Value Sold Per Day

What is Lean?

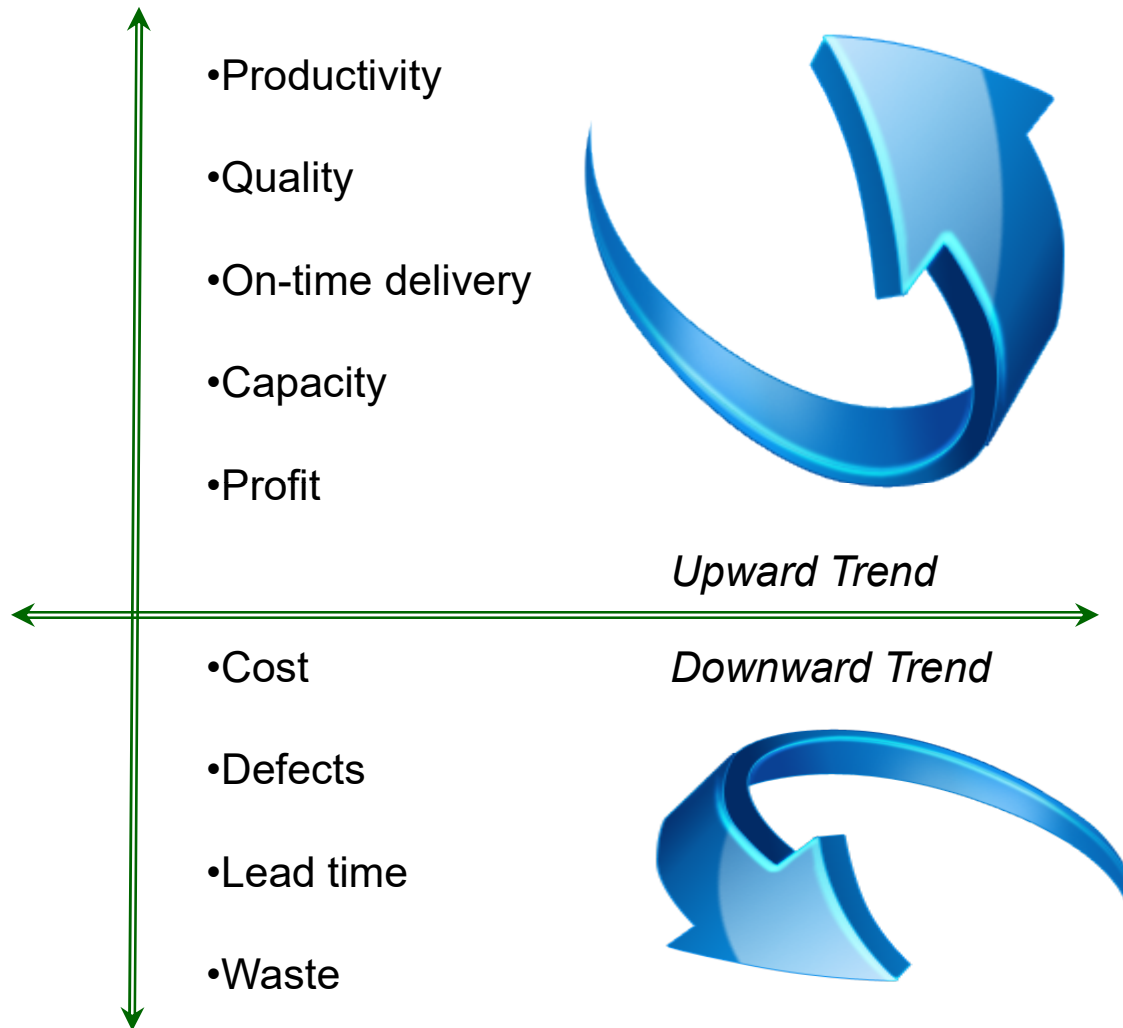
- A Strategy For Maximizing Value (speed and quality) to Customers
- The relentless pursuit of the perfect process through waste elimination(MUDA)



LEAN SIX SIGMA

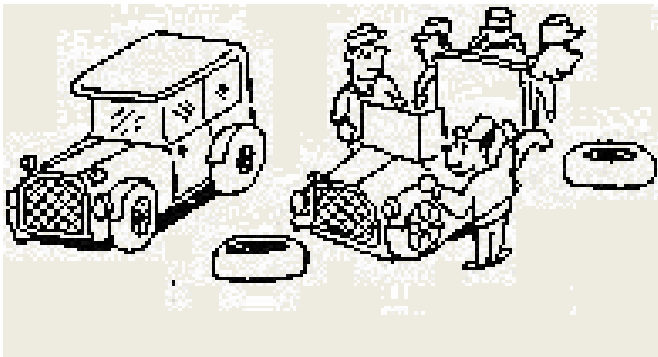
IMPROVE

By Implementing LEAN what will happen

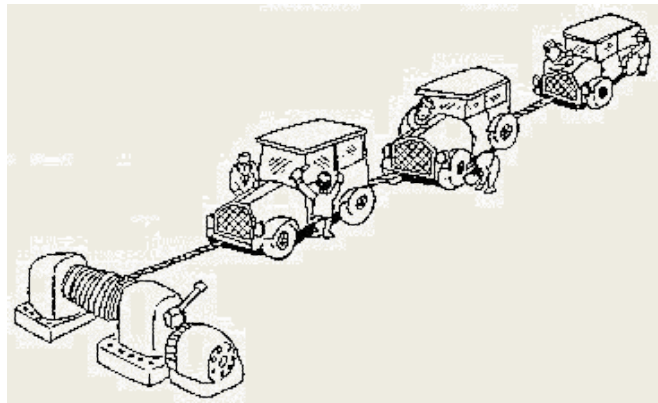


***Isn't LEAN
worth it !!!!!!!!!***

What happened in 1908?



Before: cars were built in one spot and the workers moved from car to car. This was called the “gypsy production” system.



After: Ford used a big rope and winch to pull the cars along the assembly line and kept the workers stationary

5 Lean Principles



- 1) Specify features that create value to customers.
- 2) Identify sequence of activities called value stream.
- 3) Make the activities flow.
- 4) Let the customer pull the product or service through the process.
- 5) Perfect the process

5 Lean Principles

Specify Value

Identify Value Stream

Improve Flow

Pull

Perfection

- ✓ The value is specified from the standpoint of the end customer (internal or external).
- ✓ It is expressed in terms of how the specific product meets the customer's needs at a specific price and at a specific time.
- ✓ It helps in judging customer's level of satisfaction.

5 Lean Principles

Specify Value

Identify Value Stream

Improve Flow

Pull

Perfection

- ✓ Identify all the steps (value add and non-value add) that are required to move products from order to delivery.
- ✓ Challenge every step and identify necessary operations.
- ✓ Identify necessary operations. Necessary operations are defined as being a prerequisite to other value added activities or being an essential part of the business.

5 Lean Principles

Specify Value

Identify Value Stream

Improve Flow

Pull

Perfection

- ✓ Direct improvement efforts in making the activities flow continuously.
- ✓ Continuous flow means uninterrupted movement of products, services and information through the various transactions from end to end in the process
- ✓ Avoid batch processing.
- ✓ Requires that every step in the process to be:

5 Lean Principles

Specify Value

Identify Value Stream

Improve Flow

Pull

Perfection

- ✓ Nothing is done by the upstream process until the downstream customer signals the need.
- ✓ Direct efforts to let the customer pull product or service through the process.
- ✓ Make the process responsive to customer needs only.

5 Lean Principles

Specify Value

Identify Value Stream

Improve Flow

Pull

Perfection

- ✓ Repeat efforts and attempt constantly to remove non-value adding activities from the process.
- ✓ Improve flow (from current to future state) and satisfy customers
- ✓ Create value for the customers.
- ✓ Use root cause analysis to solve problems.

5 Lean Principles

Specify Value

Identify Value Stream

Improve Flow

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Perfection

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Learn to see “Waste”

- Three Japanese Waste
 - Muda – Seven non value adding activities (Waste)
 - Mura – Unevenness
 - Muri Over burden / irrational expectation

Value & Its Type

Customer Value-added (VA):

- Any activity that adds form, feature or function.
- Any activity for which the customer is willing to pay for.
- Any activity which is produced Right the first time.

Business Value added (BVA):

- Is this task required by law or regulation?
 - Eg. Emissions, safety, factories act
- Does this task reduce financial risk of owners?
- Does this support financial reporting requirements?
- Would the process breakdown if this task were removed?

Non-value-added (NVA)

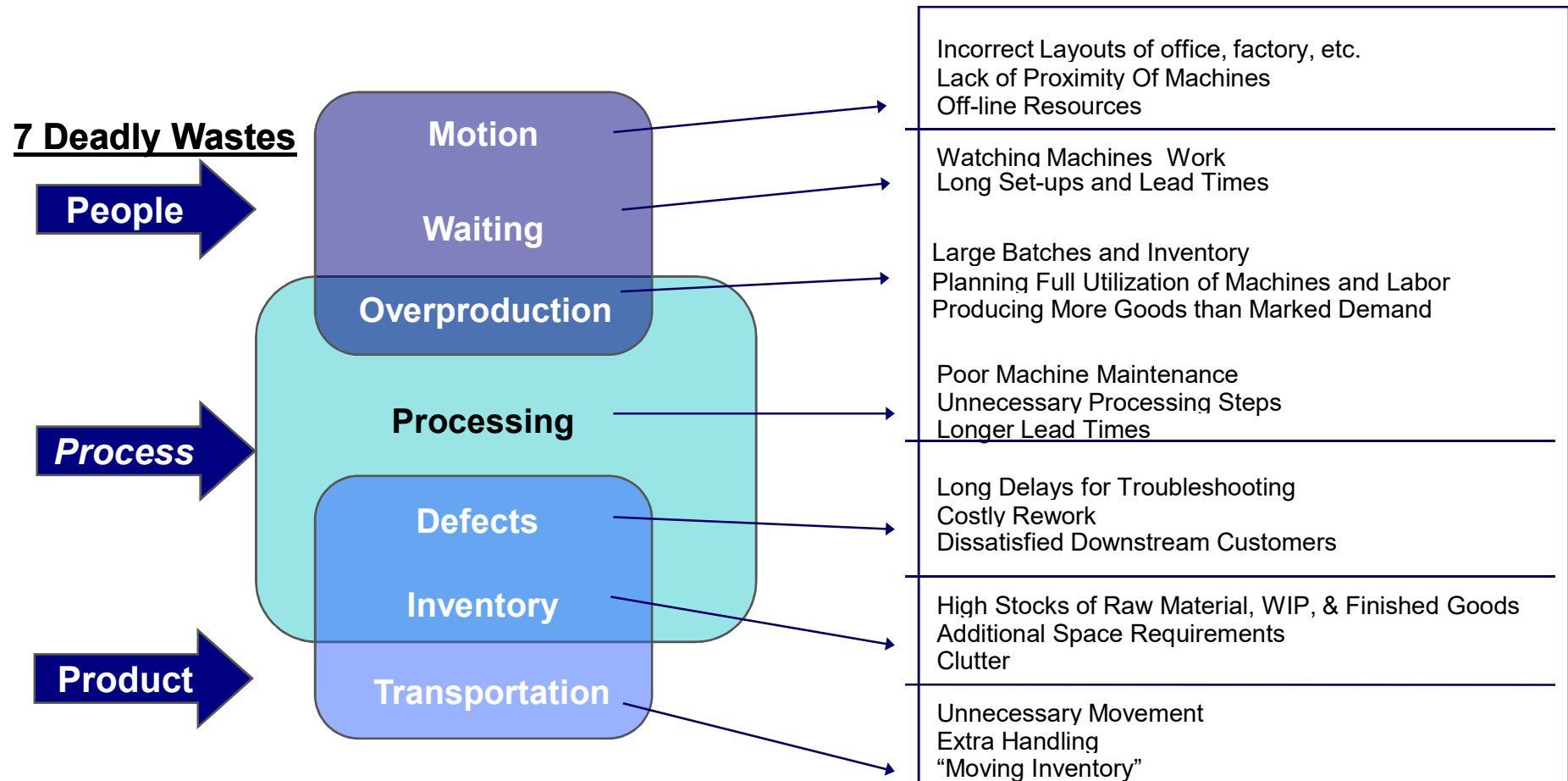
Value & Its Type

- **Value added activity** address the following question
 - Does the task add form, fit, function or feature to the product or service?
 - Does the task enable a competitive advantage (reduced price, faster delivery, fewer defects)?
 - Would the customer be willing to pay extra or prefer us over the competition?
 - Example : Dyeing, Lubricating

Value & Its Type

- **Value Enabling activity** address the following question
 - Does this task reduce owner financial risk?
 - Does this task support financial reporting requirements?
 - Would the process of producing/selling the product break down if this task were removed?
 - Is this task required by law or regulation?
 - Example : Purchasing, Regulatory reporting

MUDA – Lean is a way to continuously eliminate waste



Genchi Genbutsu – “Go and See”

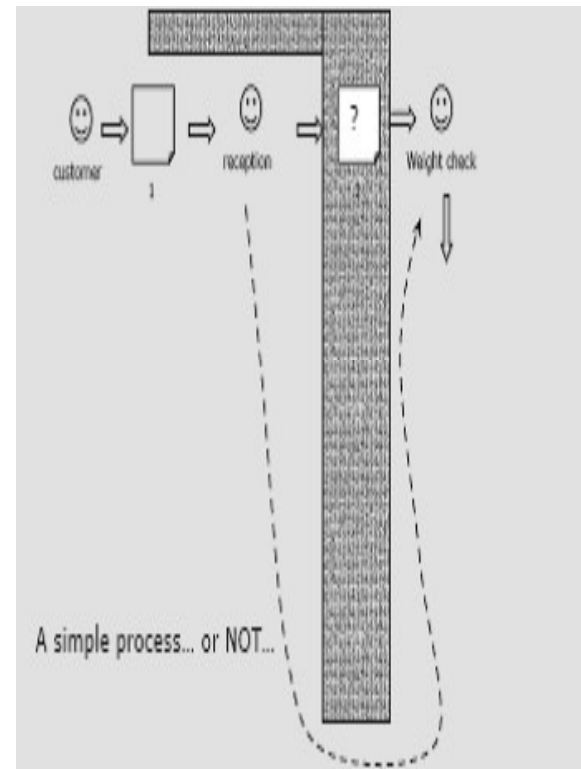
- Genchi – Actual Location
- Genbutsu – Actual Materials or Products
- Gemba – The Actual Place
- Genchi Genbutsu: Going to the actual place to see the actual situation for understanding.
- Ability to get to the root cause of the observed problem and communicate it effectively
- Hourensou: Rapid Genchi Genbutsu for Executives

Genchi Genbutsu – “Go and See”

- Think and Speak based on personally verified, proven information and data.
 - Go to the facts and confirm
 - Complete responsibility for the information reported
- Ohno Circle – Observe and Analyze yourself
- Difference between Top Management Approaches
 - Japanese: Personally go to the root cause and verify
 - Others : Manage through corporate offices

Genchi Genbutsu – “Go and See”

- Go and see for yourself to thoroughly understand the situation
- Go to the source to observe and verify data
- Don't conclude on the basis of what people and computers tell you
- Continually question Why?
- Specify the root cause.

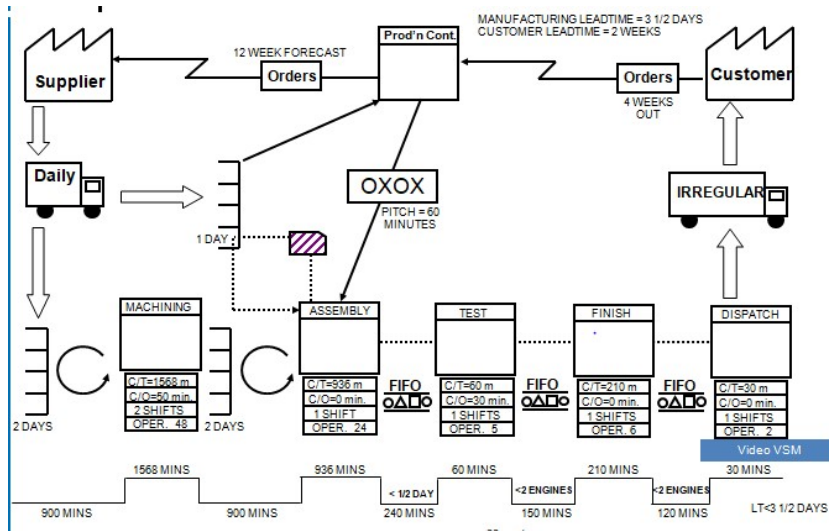


Taichi Ohno Circle

- Stand inside the circle
- Observe the process critically for wastes
 - Repeated works
 - Process interruption
 - Quality issues
 - Ergonomic issues
 - Machine breakdown
- Analyse the source and root cause of the effect
- Plan solution
- Hands on pilot implementation
- Train the stakeholders
- Rollout the solution

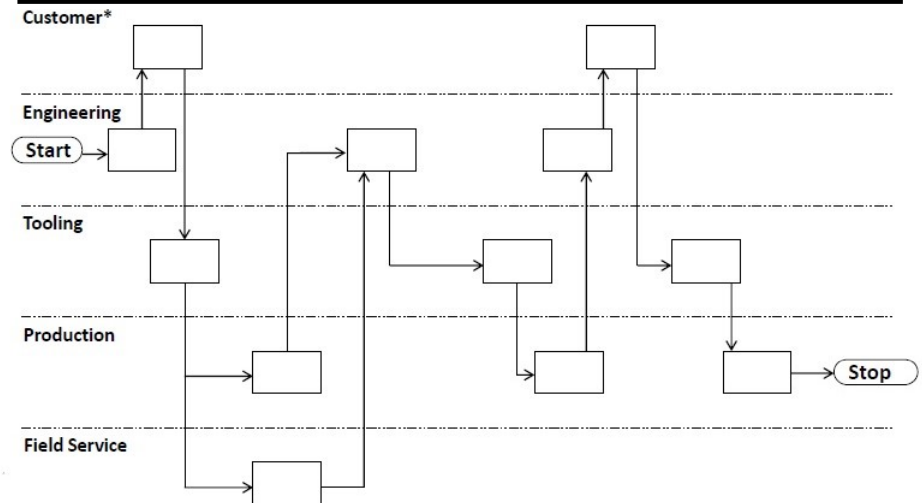


VSM (vs) Process mapping



- Customer focused
- Look at the end to end value stream
- Helps us to visualize flow
- Helps see waste and its source
- Becomes the blueprint for improvement
- Shows the linkage between information and physical flows
- "Reality Map"

Traditional process mapping



- Functional Focused
- Varies in scale from Macro to Micro functions
- Used to understand the steps in a process
- No value judgments made
- Used for continuous improvement, business planning, scoping or establishing boundaries of what and where
- Planned Map

LEAN SIX SIGMA

IMPROVE

VSM

Inventory...

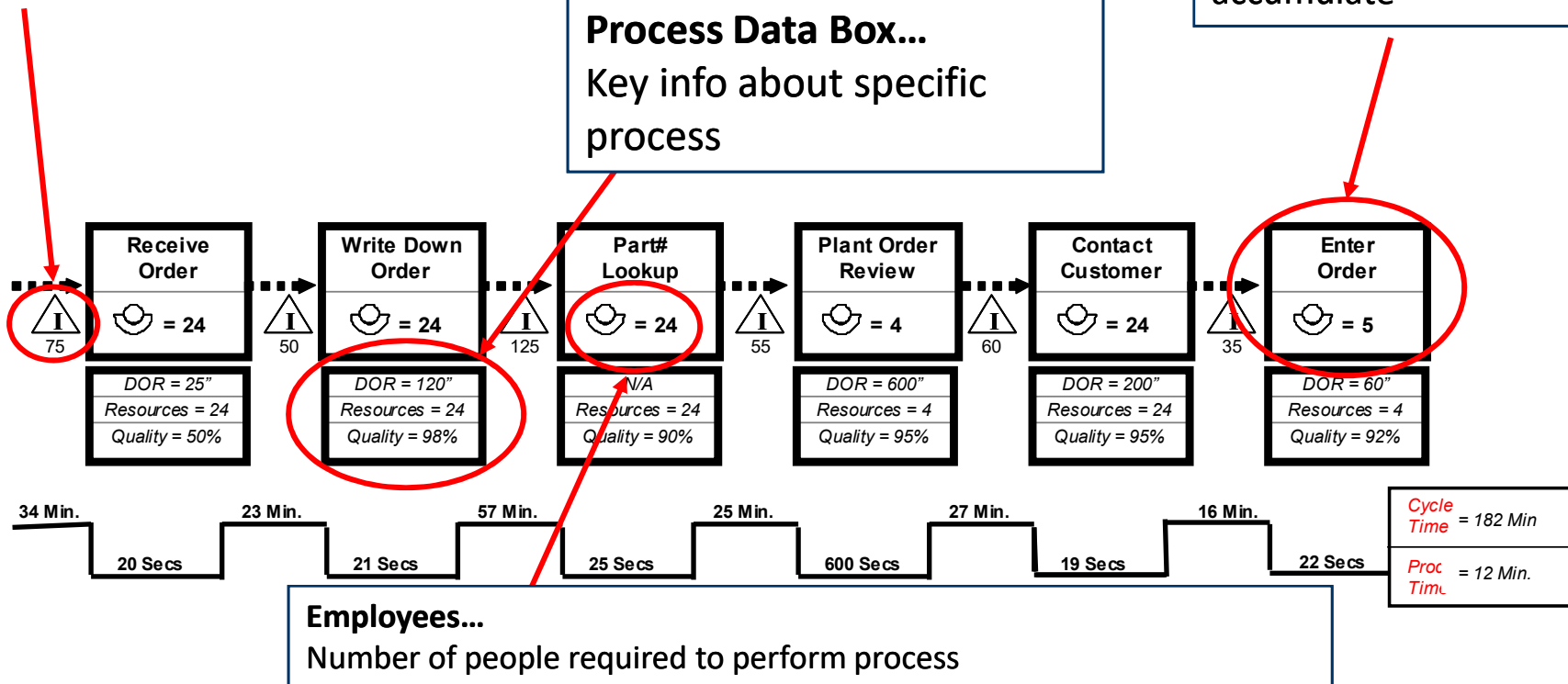
Amt sitting in queue waiting to be processed

Process Data Box...

Key info about specific process

Process Box...

A point in the value stream at which flow stops and inventory has the opportunity to accumulate



VSM metrics

Wait Time = Total wait time of a process

Processing Time = Total processing time of a process

Process Lead time = WIP * EXIT Rate

Process cycle efficiency = $\frac{\text{Value add time}}{\text{Total process lead time}}$

Yield = $\frac{\text{No of Output units from process step}}{\text{No of Input units to the process step}}$

Rolled throughput yield = Yield of P1 * Yield of P2 * Yield of P3 * Yield of P1 *

TAKT Time = $\frac{\text{Time (Available seconds per working day)}}{\text{Volume (Daily production requirement)}}$

Cycle Time = Actual time required for a worker to complete one cycle of his process

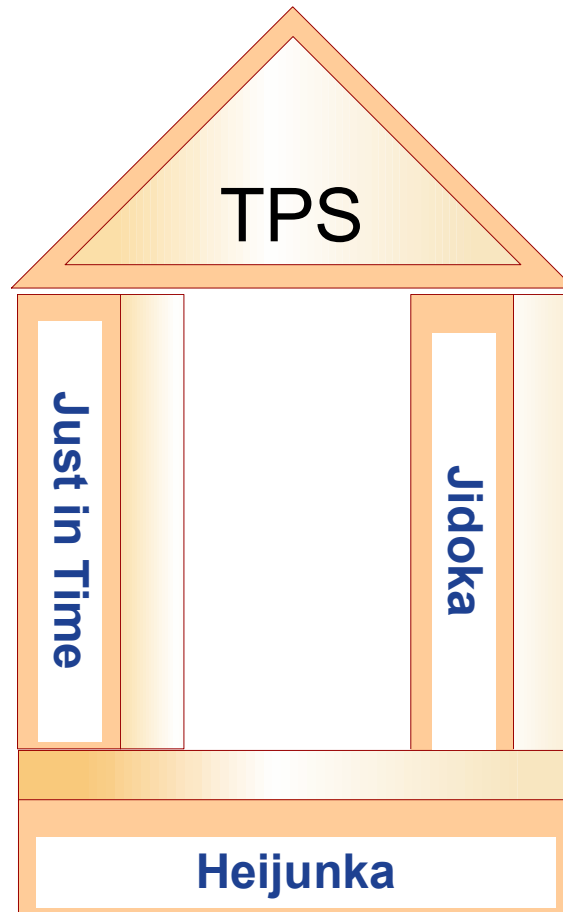
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VSM metrics

- Process Lead Time (PLT): The elapsed time between a unit entering a process until it exits the entire system
- Work In Process (WIP): The total number of work units in the entire system
- Exit Rate: The rate at which completed units exit the entire system
- $PLT = WIP / \text{Exit Rate}$

How can we improve the flow

- Standard work
- Pull Production
- TAKT Time Production



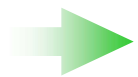
- Autonomation
- Built-in Quality
- Stopping at Abnormalities

- Leveling
- Sequencing
- Stability

Importance of standard work

1. To make process rules explicit

Establish the explicit methods for manual tasks with respect to quality, quantity, cost and safety.



prevent wastes

2. A tool for Improvement

There can be no improvement in the absence of standards.
Abnormal situation show that something is going on.



expose wastes

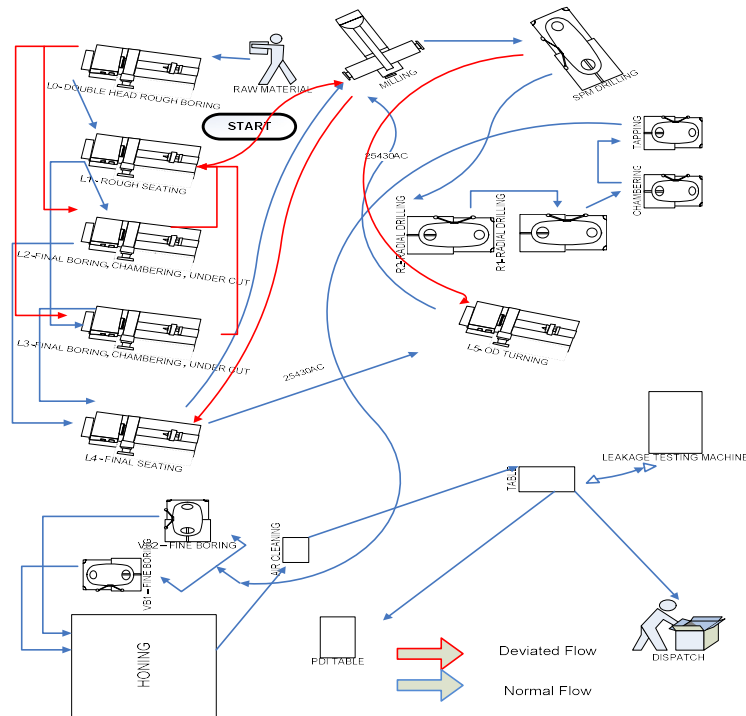
Elements of flow

Establish Flow

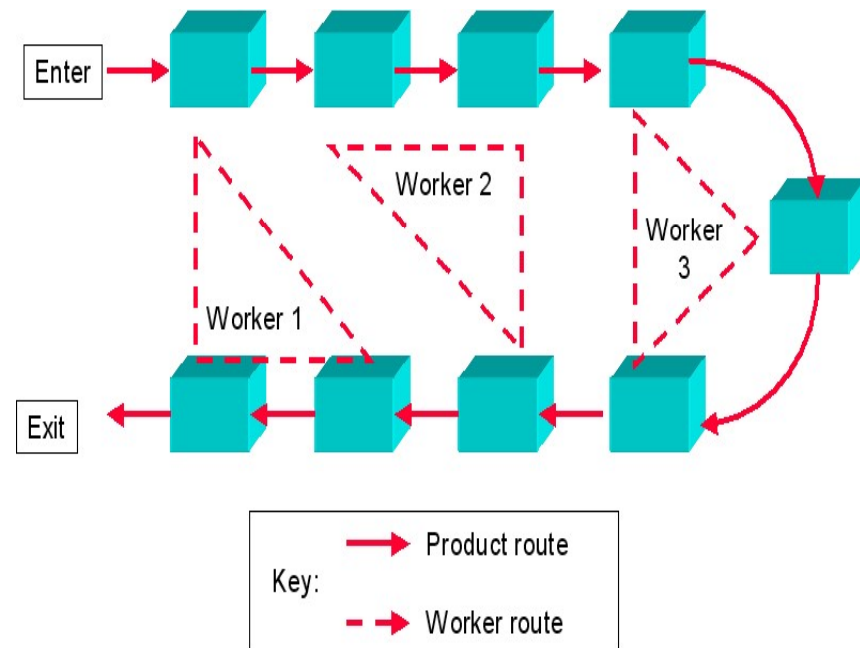
- The continuous movement of material as it is transformed from raw material to a finished product.
- Require that every step in the process be:
 - Capable – right every time
 - Available – always able to run
 - Adequate – with capacity to avoid bottlenecks and overcapitalisation (right sized tools)

Elements of flow

Bad Flow



Good Flow



Cell

What is Cell?

To form machines in sequence of production according to Process flow and Product family with minimized non value added activity(NVA)

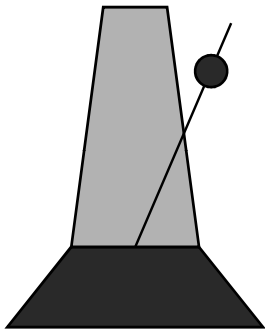
Two major objectives:

- One piece flow
- High Variety Operations

Takt Time (vs) Cycle Time

Takt Time

$$= \frac{\text{Time (Available seconds per working day)}}{\text{Volume (Daily production requirement)}}$$

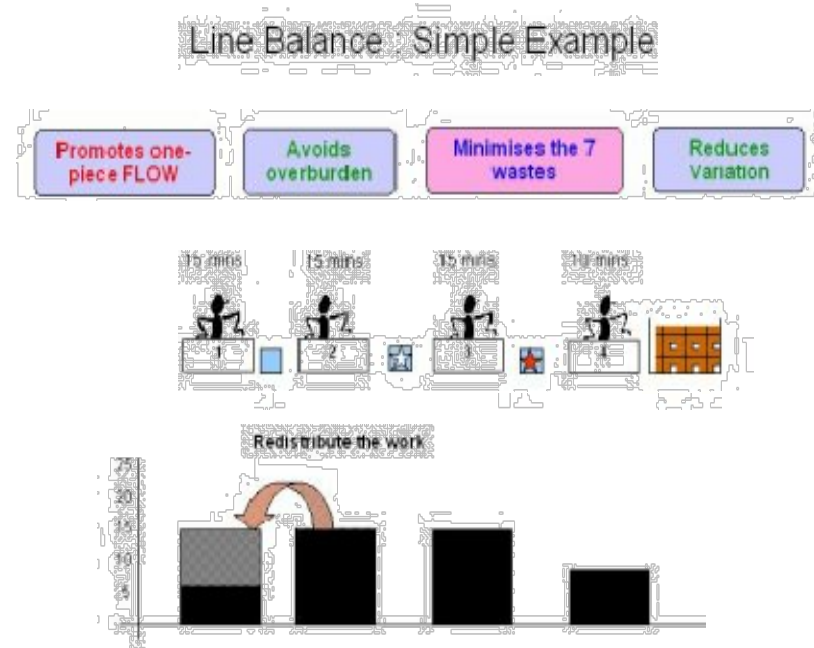
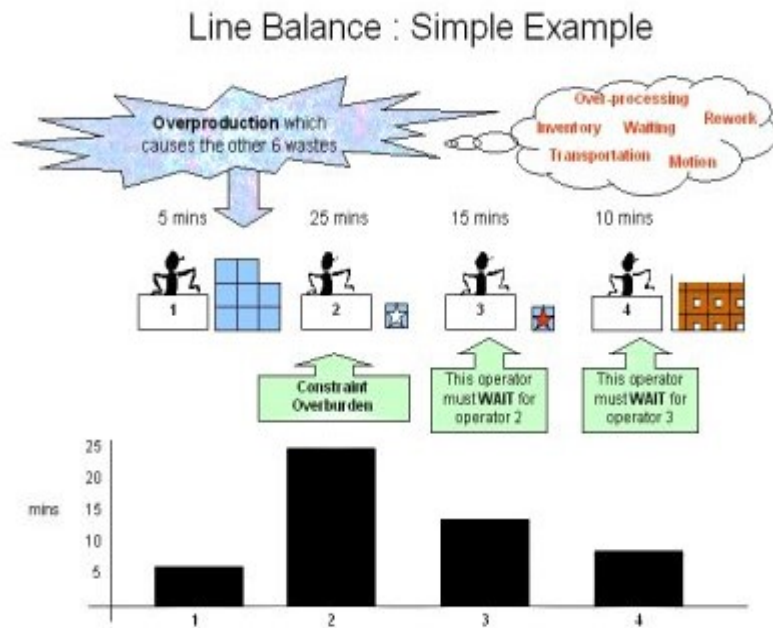


Sets pace of production to match pace of sales.

Cycle Time

$$= \text{Actual time required for a worker to complete one cycle of his process}$$

Line Balancing



- Here we see operator number 1 overproducing, thus creating the other 6 wastes.
- simply rebalance the work content

Jidoka

- **AUTOMATION**

1. Derived from word Automatic i.e only help of machine no human assistance.
2. Automatic manual process
 - (a) Waste of talent of man.
 - (b) Laziness/less output of man.
3. Replaces human involvement i.e only in operation .
4. Rarely successful.
5. Costly i.e both man and machine involved.

- **AUTONOMATION**

1. Combination of two words i.e Autonomous and Automatic.
2. Build in human intelligence.
 - (a) Evaluation of skills of operator.
 - (b) 100 % involvement of human talent for best “poke-yoke”.
3. Automatic manual process i.e no human assistance required in process.
4. Highly successful.
5. Cost effective i.e only machine involved.

Poka Yoke

- **Poka** mean **unintended error** , **Yoke** mean **to avoid**.

Why Poka yoke?

- Can we make sure to **get it right first time**?
- Do we learn from our mistake?
- Is it possible to ensure that mistake would never be repeated?
- Is it possible to correct human and machine error at or near the source?

Poka Yoke

Effect	Prevention	Detection
Force control	Physical contact or electronic control prevents the mistake from being made.	Physical contact or electronic control prevents the mistake from getting out to the customer.
Shutdown	The process is shut down before the mistake can be made	The process is shut down immediately after a mistake is detected
Warning	A warning light or audible alarm signals that a mistake is about to be made	A warning light or audible alarm signals that a mistake has just been made
Sensory Alert	A visual or other sensory cue is given that a mistake is about to be made	A visual or other sensory cue is given that a mistake has just been made

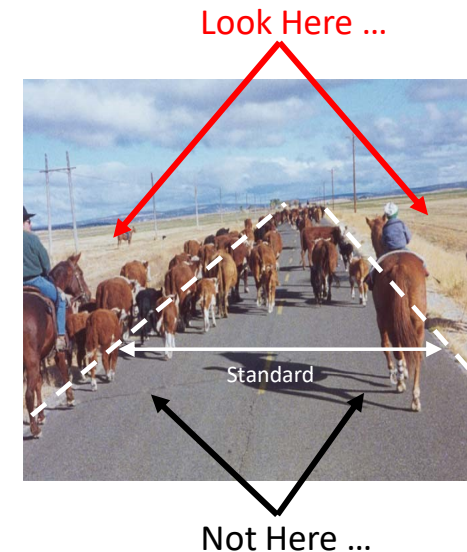
Visual Management

Don't "Manage" a Standard ... Detect the Abnormality

Make everything visible to everyone

- Expose waste
- Make standards clear
- Improve efficiency

Transparency for Continuous Improvement



Visual displays



GEMS India
Accounts Payable

5S - Seiri, Seiton, Seiso, Seiketsu & Shitsuke

- **Seiri** SORT
- **Seiton** SET IN ORDER
- **Seiso** SHINE
- **Seiketsu** STANDARDIZE
- **Shitsuke** SUSTAIN



5S - Seiri, Seiton, Seiso, Seiketsu & Shitsuke

- **Sort**
 - Separate and remove clutter and items unneeded in the workspace.
 - Extraneous items impede the flow of work.
- **Set in Order**
 - Organize what is left to minimize movement and make things clear.
- **Shine (and inspect)**
 - Clean area, storage, equipment, etc. and inspect for warning signs of breakdowns.
- **Standardize**
 - Set up an area with 5-S supplies (cleaning supplies, labels, colored tape, other organizational items) and schedule time and responsibility for restoring work area to its proper condition regularly.
- **Sustain**
 - Audit area regularly, expand 5-S to other areas.

5S - Seiri, Seiton, Seiso, Seiketsu & Shitsuke

Before 5S



After 5S



Push (vs) Pull

PUSH

- Based on forecasting
- No signal when to start or when to stop
- High waste
- Suitable only for High volume environment

PULL

- Based on customer demand
- Kanban card used as signal to start or stop
- High customization
- Low waste
- Suitable for any environment

Kanban Card

- Kanban is a Japanese word it means **card signal**
- It is a process or system it produce a continuous flow of material utilizing flexibility and lean manufacturing concept

Heijunka – Leveled Production

- Heijunka is defined as “The distribution of production volume and mix evenly over time”

Traditional Production Scheduling

- **Large Batches:** Increases The Lead Time, Defect Liability Is More, Increases The Inventory Level.
- **Low Product Variation:** No Flexibility According To The Volatile Market Demand
- **Minimize Set Up Time:** Incorporated Into Lean Manufacturing.
- **Largest Order Runs First:** High Order To Cash Value Period, Large Lead Time.

Heijunka – Leveled Production Benefits

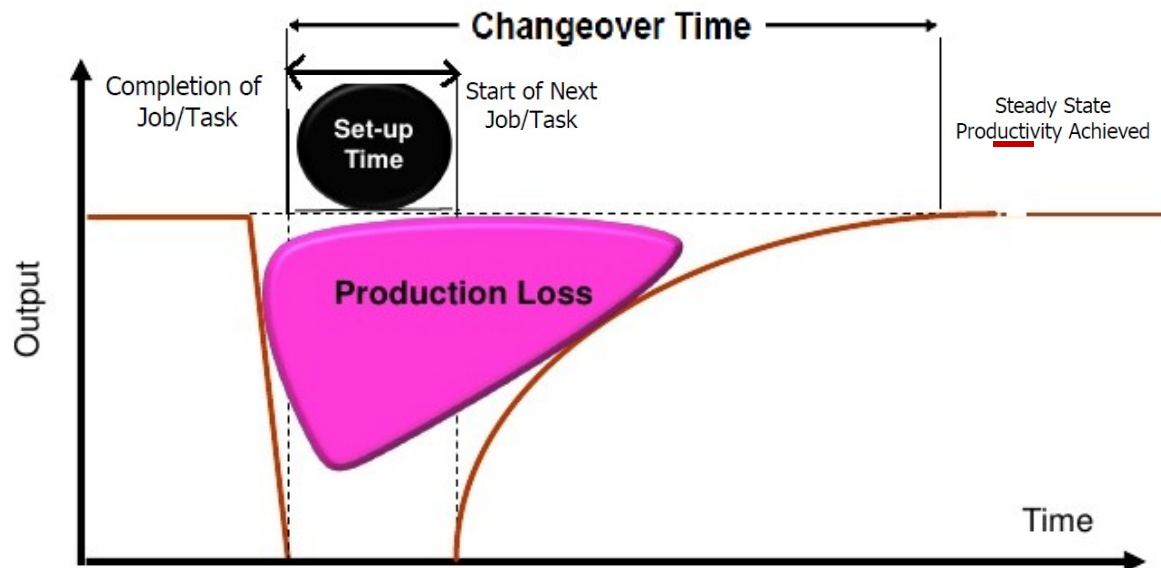
- Lead Time Reduction
- Reduction In Defects
- Flexibility
- Inventory Reduction
- Reduction In Order To Cash Cycle

Heijunka – How To Do Heijunka

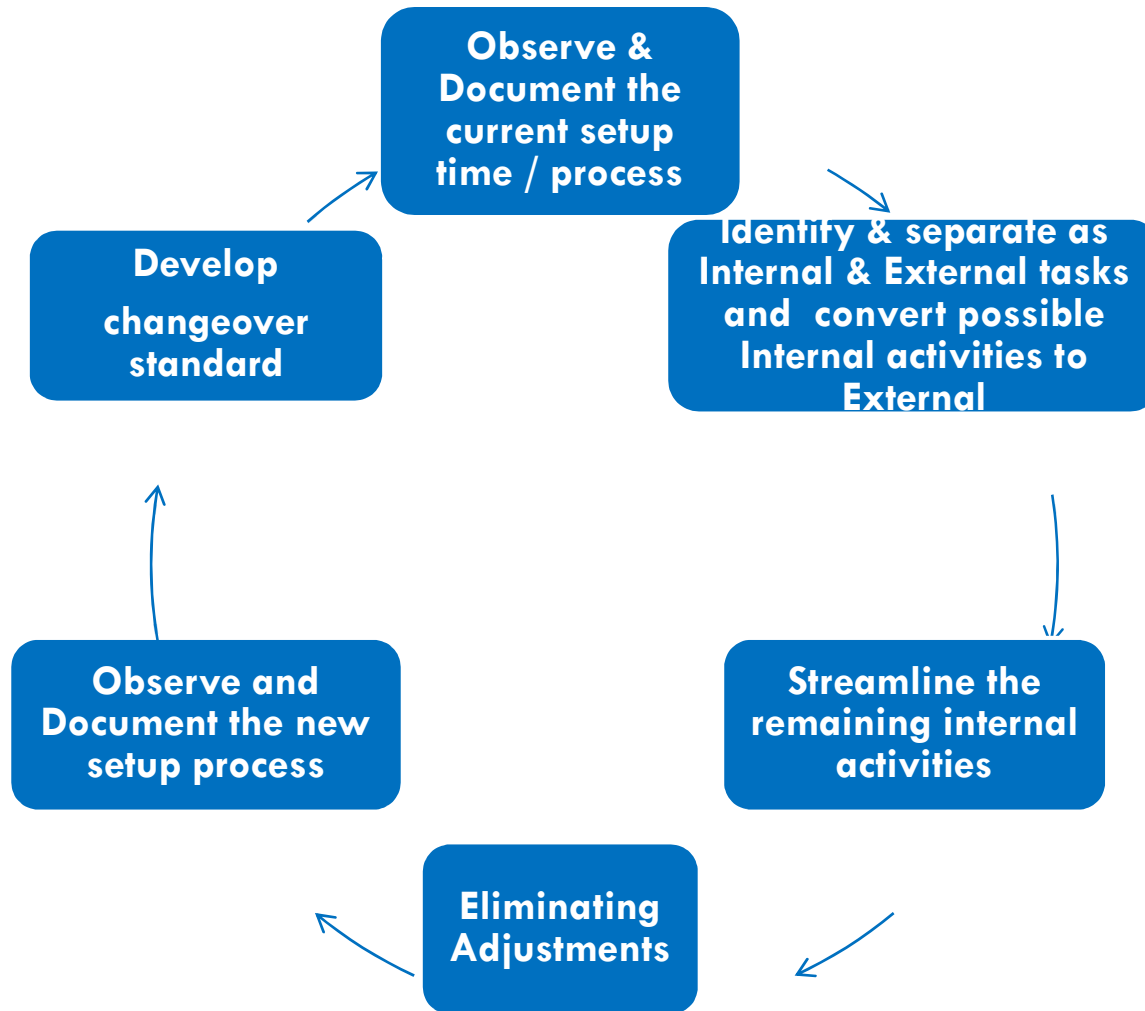
- Level Pull kanban System
- Level Pace Takt Time Altering, SMED
- Level Sequencing Heijunka Calculation Using Every Part Every X (EPEX)
- Heijunka Ratio = $\frac{\text{No of types of product}}{\text{Fulfillment Time Period}}$

Heijunka – SMED

- Definition of setup and changeover time
- Setup time typically spent
- Benefits of changeover reduction
- 6 stage changeover reduction process Internal vs external activities
- Changeover reduction



Heijunka – SMED



Kaizen

Kaizen is a Japanese term meaning "change for the better" or "continuous improvement." It is a Japanese business philosophy regarding the processes that continuously improve operations and involve all employees. Kaizen sees improvement in productivity as a gradual and methodical process.

改善

Kai = Change

Zen = Good

Kaizen – Team rules

- Be open to change
- Maintain a positive attitude
- Practice mutual respect
- Treat others as you want to be treated
- One person, one vote – position doesn't matter
- The only stupid questions are the ones not asked
- Have fun!
- Understand the process, and...**JUST DO IT!**



Lean is a way of thinking- not a list
of things to do

— *Shigeo Shingo* —

