Section I

Overview

Agenda

- ✓About Lean Six Sigma Black Belt (LSSBB)
- ✓Organizational Roadblocks
- ✓Role of Communication and Selection Criteria in Black Belt
- ✓Overview of Continuous Improvement
- ✓Lean – An Overview
- ✓Lean Concepts Explained
- ✓Lean Tools Explained

Section I, Lesson 1

About LSSBB

Agenda

- ✓What is Six Sigma
- ✓Six Sigma Roles and Responsibilities
- ✓About Lean Six Sigma Black Belt
- ✓Lean Six Sigma Black Belt Roles and Responsibilities

What is Six Sigma

- ✓Six Sigma a business philosophy focusing on continuous improvement.
- ✓It is a set of tools and strategies for process improvement.
- ✓It seeks to improve the quality of process outputs by identifying and removing any cause of defects and by minimizing variability in manufacturing and business processes.
- ✓A Six Sigma defect is defined as anything outside the original customer specifications.
- ✓To achieve Six Sigma level, a process must not produce more than 3.4 defects per million opportunities. 99.99966% of the products manufactured are statistically expected to be defect-free.

Six Sigma Roles and Responsibilities

Role	Responsibilities
Sponsor	Senior executive; sponsors Six Sigma initiative
Champion	Mid-level executive evangelizing Six Sigma; provides resources, and resolves any cross-functional issues
Master Black Belt	Black Belt with several Six Sigma projects experience; coaches, mentors, and trains Black Belts
Black Belt	Full-time professional; leads large Six Sigma projects
Green Belt	Part-time professional; leads smaller Six Sigma projects
Team Member	Brings relevant experience to a particular Six Sigma project
Process Owner	Professional responsible and accountable for the business process that is been improved in the Six Sigma project

About LSSBB

- ✓LSSBB stands for Lean Six Sigma Black Belt.
- ✓Black Belts are official team leaders of enterprise wide Six Sigma based improvement projects.
- ✓Black Belts form the main interface and communication channel between top management, Master Black Belts, and Six Sigma teams.
- ✓LSS Black Belts are experienced with advanced statistical tools know-how and can mentor Six Sigma Green Belts in using the right set of tools for completing Six Sigma and Lean projects successfully.
- ✓LSS Black Belts are expected to complete large-scale enterprise wide projects resulting in aggregate financial benefits worth at least $200,000 yearly to the organization as tangible benefits.
- ✓LSS Black Belts are full time roles.

LSSBB Roles and Responsibilities

- ✓Ensure Champion's/Sponsor's scoped objective is translated to one or more full-scale Lean Six Sigma projects.
- ✓Validate and setup **necessary** measurement systems and KPIs (Key Performance Indicators).
- ✓Provide technical expertise to Green Belts when needed.
- ✓Train Green Belts.
- ✓Liaise with top management officials.
- ✓Ensure communication is maintained in a typical Lean Six Sigma top down approach.
- ✓Conduct Six Sigma toll-gate / review meetings with top management.
- ✓Close projects successfully.
- ✓Report on regular basis the status and progress of all the projects.
- ✓On project closure, work with finance team and document project results, and share success stories across organization.

Summary

We have covered the following in this lesson:

- ✓Overview of Six Sigma and what it means in terms of defects, quality, etc.
- ✓Six Sigma as a business philosophy.
- ✓Key Six Sigma Roles in an organization.
- ✓Lean Six Sigma Black Belt, types of projects, etc.
- ✓Roles and responsibilities of Lean Six Sigma Black Belt professionals.

Section I, Lesson 2

Organizational Roadblocks

Agenda

- ✓Traditional Organization versus Customer Driven Organization
- ✓Types of Organizational Roadblocks
- ✓Change Resistance Curve
- ✓Common Resistance Points
- ✓Overcoming Resistance Points
- ✓Force Field Analysis

Traditional Organization versus Customer Driven Organization

Traditional organization

- ✓ **Product and planning**
  - Short term focus
  - Reactionary management
- ✓ **Performance measure**
  - Quick ROI
- ✓ **Attitude to customers**
  - Customers are hostile
  - Customers are bottlenecks
- ✓ **Process management**
  - Error and defect reduction

Customer driven organization

- ✓ **Product and planning**
  - Long term focus
  - Preventive management
- ✓ **Performance measure**
  - Based on CSAT
- ✓ **Attitude to customers**
  - Customers are the king
  - Customers need to be respected
- ✓ **Process management**
  - Error and defect prevention

Types of Organizational Roadblocks

1. **Lean Six Sigma is a fad**

✓By who –

- Expressed by top leadership.

✓When and why –

- After hearing preliminary things about Lean and Six Sigma.

✓How to deal with it –

- Show them the benefits of Lean Six Sigma by implementing a small scale pilot project or suggesting an implementation.

2. **Lean Six Sigma is too statistical**

✓By who –

- Expressed by top leadership and also employees.

✓When and why –

- After learning Six Sigma is a statistical approach.

✓How to deal with it –

- Black belts can help them overcome this resistance by explaining one or two statistical tools.

Types of Organizational Roadblocks (Contd.)

3. Why should one change?

- ✓By who –
  - Expressed by top leadership.
- ✓When and why –
  - After hearing Lean Six Sigma will enforce a culture change.
- ✓How to deal with it –
  - By explaining change is imperative. It helps in keeping an organization competitive in the market.
- ✓By who –
  - Expressed by employees.
- ✓When and why –
  - Employees enjoy being in a comfort zone.
- ✓How to deal with it –
  - By changing, competitiveness to the organization can be ensured, along with upgrading the skills.

Types of Organizational Roadblocks (Contd.)

4. **Non – cooperation from employees**

✓By who –

- Expressed by employees.

✓When and why –

- Typically happens while implementing new process, due to resistance to adapt to new processes.
- Also, due to fear of admitting mistakes of the past.

✓How to deal with it –

- Build trust in employees that they wouldn't be penalized for past mistakes.
- Encourage the "Move Ahead" philosophy.
- Ensure employees are involved in designing and setting up the new processes.

The starting point is: To communicate and ensure employees are convinced **not to resist change.**

Important: No use of 'force tactics' to convince employees.

Types of Organizational Roadblocks (Contd.)

5. Wrong team members

✓By who –

- Observed within the team members.

✓When and why –

- Happens when a team has several members possessing the same skill-sets. Duplication of thoughts leads to change efforts falling flat. No creativity or lack of creativity in ideas is perceived.

✓How to deal with it –

- Choose team members on different skill-sets.
- Choose team members based on four factors:
  - Capability;
  - Creativity;
  - Willingness; and
  - Ability.

Types of Organizational Roadblocks (Contd.)

6. Fear of measurements

✓By who –

- By employees.

✓When and why –

- As things get measured, people become reluctant. They fear that their performance will get measured which might involve additional scrutiny. They fear that it will impact their performance reviews.

✓How to deal with it –

- Provide confidence to employees that the measurement will be only used to improve the process and not people.
- The data will never be used for performance reviews.

Types of Organizational Roadblocks (Contd.)

7. Fear of job elimination

✓By who –

- Observed within team members.

✓When and why –

- As things improve, less people will be needed to get the work done and as a result of people may lose job.

✓How to deal with it –

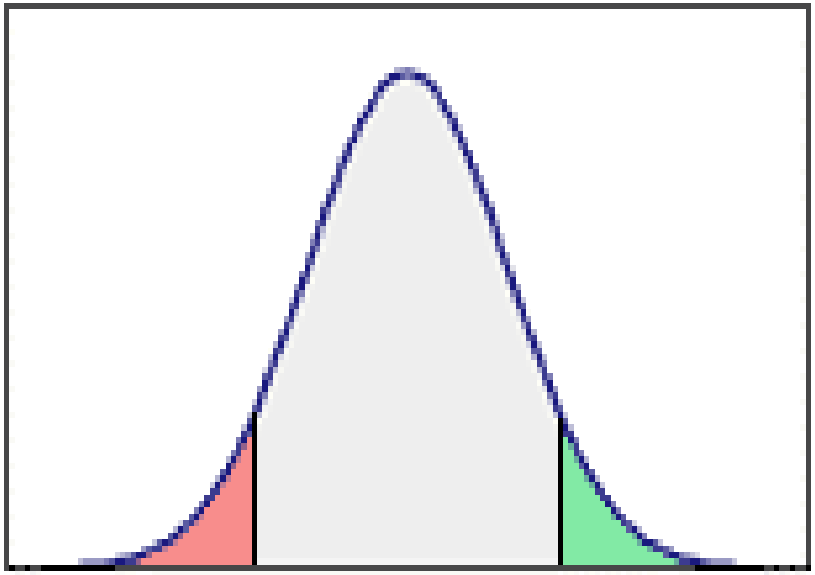
- Provide confidence to employee that the improvements will lead to doing more with less.
- Improvements will lead to better quality, lower cost, and higher profit. Will help people to have jobs even in tough times.

Types of Organizational Roadblocks (Contd.)

Black Belts' role in dealing with organizational roadblocks

- ✓Communicating the change efforts from the top management to all employees.
- ✓Ensuring incentive and reward schemes for projects are identified, communicated to top management, followed up with top management, and communicated back to the employees .
- ✓Communicate effectively and ensure transparency amongst team members.
- ✓Play an important and neutral role in selecting Six Sigma team (BB: GB Ratio to be 1:6).
- ✓Provide confidence that measurements and improvements are for overall organization's good and aligns with broader goal. The data collected will not be used to measure performance.

Change Resistance Curve



The Attitude Bell Curve

Which area would you focus more on?

Source: http://www.mentalgamecoach.com/articles/ManagingChange.html

Change Resistance Curve (Contd.)

Organizations are split into:

15% supportive, 70% neutral, and 15% resistant.

- ✓Don't bother about 15% supportive as they would support change anyways.
- ✓Don't bother about 15% resistant as they would resist change anyways.
- ✓Spending any time with the resistant population is a waste.

Why?

- ✓Focus on the 70% neutral and get them moving with the change.
- ✓The resistant minority is the most vocal opposing any possible change effort.
- ✓By being vocal, it is able to distract organization's management.
- ✓If the management gets distracted, the 70% neutral majority will feel that the management wasn't serious about the change.

What happens to the resistors then?

Change Resistance Curve (Contd.)

- The 15% supportive population would always support the change effort.
- If focus is on working with the 70% neutral populace, they can move to the supportive section.
- The 15% resistant population now is in absolute minority with no possibility of neutral folks joining them.
- When 85% of the people are embracing the change and the benefits are seen, the 15% resistant population will slowly start moving to the supportive zone.
- In most cases, the 15% resistant people move over to **support the change effort, fearing isolation**.

Important: Always work on the 70% neutral category to enable them to overcome change resistance.

Common Resistance Points

Common factors or points showing resistance to change are:

✓**Ignore the new process or the change**

- Thought – Ignore the new process and it will fade away.
- When – Usually happens with teams that are established and have delivered results with the earlier process.

✓**Fail to understand**

- Thought – By expressing their inability to comprehend on a regular basis, make it tough for change efforts to bear fruit.
- When – Typically happens with teams that are established. Moderate experience teams typically do not do this as they fear that it may backfire.

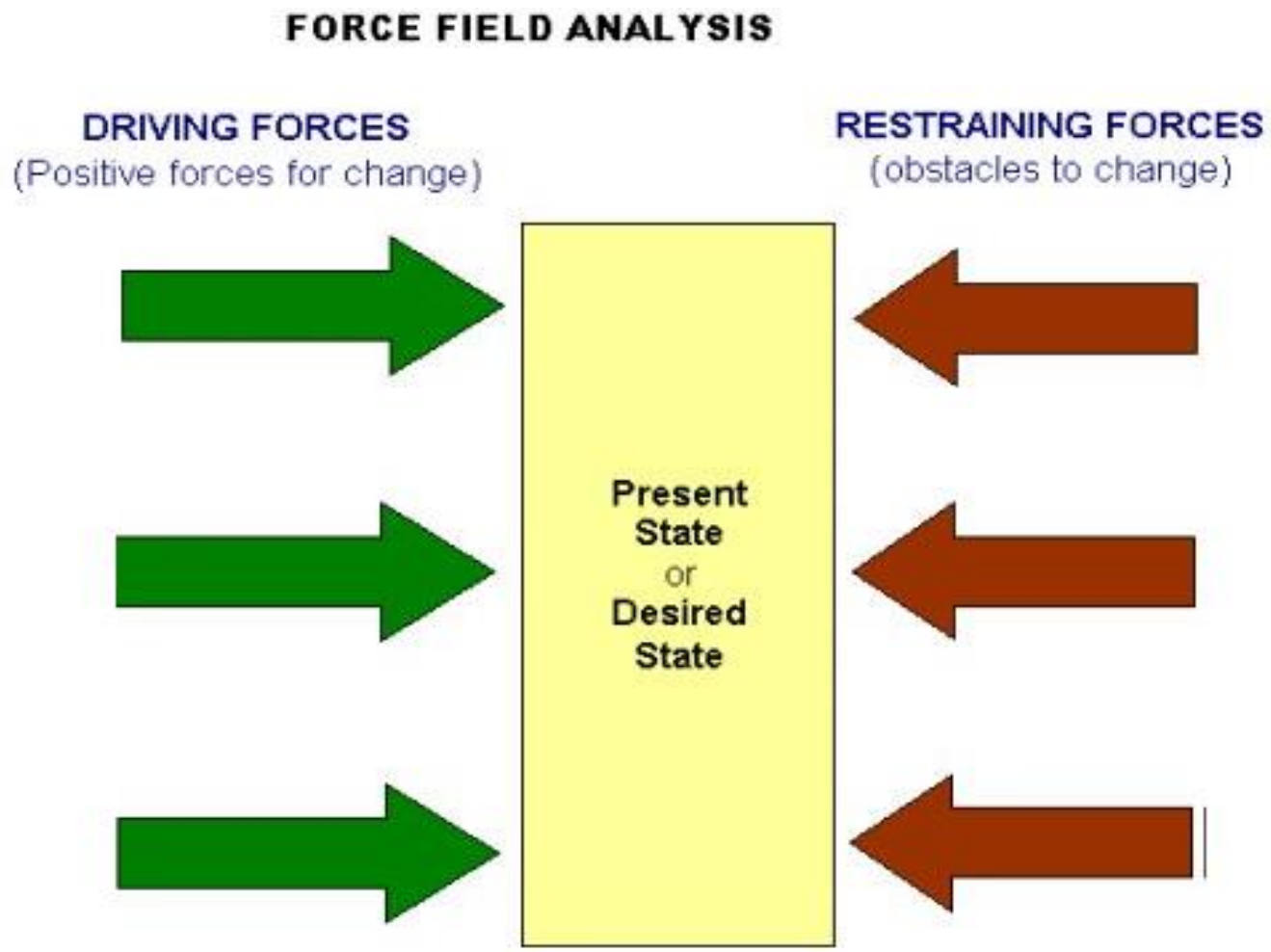
Common Resistance Points (Contd.)

- **Disagree with the validity of the benefits**
  - Thought – By disagreeing, the management can and will re-think on introducing the change.
  - When – The benefits, calculations, and projections are not based on standard company practices and norms.
- **Criticize new set of tools or applications**
  - Thought – By talking about challenges and shortcomings of the new tools and impact on productivity, the management will abandon the new set of tools.
  - When – The team members have not been involved for identifying the right set of tools and applications for the improvements.
- **Delay the implementation**
  - Thought – Delaying implementation reduces the interest in the change and delays the overall benefits realization.
  - When – Team members do not want to be vocal about resistance as they fear it may backfire. They adopt this technique of delaying it.

Overcoming Resistance Points

Resistance point	How to overcome/Approach
Ignore the new process	Involve few folks while creating new process
Inaccurate understanding	Newsletters, check sheets, one-one
Disagree with validity	Use standard measurement and benchmarking technique and involving them in calculations
Criticizing tools or applications	Feedback loop, weekly reviews
Delaying the implementation	Communicate the need for immediate change and incentivize

Force Field Analysis



Source: http://www.change-management-coach.com/force-field-analysis.html

Force Field Analysis (Contd.)

- ✓Conceived by Kurt Lewin.
- ✓The thought – "An issue is held in balance by interaction of two opposing sets of forces – those that seek to promote change and those that seek to maintain status quo."
- ✓Forces that seek to promote change – Driving forces.
- ✓Forces that seek to restrain change – Restraining forces.

Driving force = Restraining forces → No change possible.

Driving forces < Restraining forces → Negative change or undesirable change.

Driving forces > Restraining forces → Change accomplished.

Force Field Analysis (Contd.)

Steps to do force field analysis

1. Define the future change – Write the goal or future state.
2. **Brainstorm** the driving forces – Write down factors that are **FOR** the change.
3. **Brainstorm** the restraining forces – Write down factors that are **AGAINST** the change.
4. Evaluate the forces – Rate the driving and restraining forces on a scale of 1 – 5 (1 being weak and 5 being strong.)
5. Review the rating – Check for flexibility in the forces.
6. Strategize and prioritize – Brainstorm with team on possible counter-action plan.

Force Field Analysis (Contd.)

Limitations of force field analysis

1. Amount of subjectivity involved in assigning ratings to driving forces.
2. Concept of force field analysis applicable only in limited settings and is not a universal model.
3. Confusion in assigning one-off force as a responsible factor.
4. Possible chance of a bias.

Important: Force field analysis is one of the first pre-define tools to be used by an LSS Black Belt.

Use the tool, force field analysis template, provided as a word document in the toolkit.

Summary

We have covered the following in this lesson:

- ✓Difference between traditional and customer driven organization
- ✓Organizational roadblocks details
- ✓Black Belt's role in overcoming roadblocks
- ✓Change resistance curve
- ✓Common resistance points and overcoming them
- ✓Force field analysis

Section I, Lesson 3

Role of Communication and Selection Criteria in Black Belt

Agenda

- ✓Black Belt Role Summary
- ✓Black Belt Communication Expectations
- ✓Black Belt Selection Criteria

Black Belt Role Summary

- ✓A Black Belt's primary role is to help the Green Belt and Six Sigma teams to deliver successful project.
- ✓Black Belt need to handle obstacles and help the team overcome them.
- ✓Black Belts extract knowledge from the organization's information warehouse.
- ✓A Black Belt is also considered a full time change agent.
- ✓As a change agent, a Black Belt must be able to think and enable changes in their organizations.
- ✓Black Belt must be trained in the tools, techniques to mentor large improvement projects, and have access to software and hardware resources.

Black Belt Communication Expectations

How should a Black Belt communicate?

1) Must be able to communicate effectively verbally and in written.
2) Must be able to communicate in private as well is in public.
3) Must be able to work proactively and not reactively.
4) Must be able to work in small settings.
5) Must be able to work as a participant, especially in some meetings.
6) Must be able to comprehend top management instructions.
7) Must be able to translate top management expectations and instructions into project goals and actions.
8) Send detailed project status report on weekly/fortnight basis.
9) Conduct periodic project reviews and toll-gate reviews with executives.

Important: The above mentioned points will help the Black Belt perform their role effectively and have a bigger impact on the project. Without these interpersonal skills, a Black Belt is inefficient in his or her role.

Black Belt Selection Criteria

Black Belts should be selected based on weight grading on factors below:

Overcoming obstacles – 34%;

Attitude – 26%;

Logical thought process – 13%;

Communication skills – 9%;

Data interpretation ability – 8%;

Team handling experience – 5%; and

Mathematical skills – 5%.

A degree in mathematics is not a mandatory requirement for Black Belts. But it is expected that they can understand statistics and get trained in statistical software like Minitab and have good analytics skills.

Summary

We have covered the following in this lesson:

- ✓Overview of Black Belt role
- ✓Expectations from Black Belt on communication
- ✓Selection criteria for Black Belt

Section I, Lesson 4

Overview of Continuous Improvement

Agenda

- ✓Continual Improvement Process
- ✓Continuous versus Continual Improvement
- ✓Kaizen

Continual Improvement Process

- ✓Continual improvement process or CIP is a steady effort made to improve existing processes, products, or services.
- ✓Delivery processes are evaluated against efficiency, effectiveness, and flexibility.
- ✓ William Edwards Deming quotes, “CIP is a part of the system, where feedback from the process and the customers are evaluated against organizational goals.”
- ✓ Principle of CIP is feedback.
- ✓Purpose of CIP is to identify, reduce, and eliminate below optimal processes.
- ✓Emphasis of CIP is to take gradual and incremental steps.

Continuous versus Continual Improvement

- ✓The word continuous should be used when events happen continuously at regular intervals.
- ✓The word continual should be used when events happen in a continuous fashion in discrete jumps.
- ✓By convention, usage of the word continuous improvement is more popular. Experts and businesses though have started to use the word continual improvement.

Important – Use the term continual improvement of processes and continuous improvement in data trends.

Kaizen – Continual Improvement

- ✓Most successful implementations use kaizen as their base approach for continual improvement.
- ✓Kaizen stands for “Change for the Better.”
- ✓The cycle of kaizen activities is also known as the PDCA or Deming cycle, mentioned first by Dr. William Edwards Deming.
- ✓One kaizen variant is kaizen blitz or kaizen burst.
- ✓Kaizen blitz emphasizes on rapid or breakthrough improvement, and it is a focused activity on a particular process. Example, McDonalds inscribing the temperature regulations on their water carrying glasses.
- ✓Masaaki Imai made the term "Kaizen" famous in his book Kaizen: “*The Key to Japan's Competitive Success.*”

Kaizen – Continual Improvement (Contd.)

5 elements of kaizen

- ✓Teamwork
- ✓Personal discipline
- ✓Improve morale
- ✓Quality circles
- ✓Suggestions for improvement

The kaizen cycle

- ✓Standardize the operation and activities
- ✓Measure the operation
- ✓Compare measurement to requirements
- ✓Innovate to meet requirements and increase productivity
- ✓Standardize new operations and continue the cycle ad infinitum

Summary

We have covered the following in this lesson:

- ✓Continual improvement process
- ✓Continuous versus continual improvement
- ✓Kaizen approach for continual improvement

Section I, Lesson 5

Lean – An Overview

Agenda

- ✓What is Lean
- ✓History of Lean
- ✓Principles of Lean
- ✓Key Benefits of Implementing Lean
- ✓Why Lean before Six Sigma

What is Lean

- ✓Lean is a principle of eliminating waste (muda) and reducing non-value added activities.
  - Waste is anything unnecessary for the process.
  - Non-value adding activity is any activity the customer is not willing to pay for, or one that doesn't add value to the product.
- ✓Lean helps in increasing the speed of the product manufacturing process.

History of Lean

In chronological order, the history of Lean is presented below:

- ✓1911 – Fredrick Winslow Taylor, father of scientific management, introduces the concept of standardization.
- ✓1922 – Henry Ford spoke about waste reduction as a key principle of improving efficiency in "My Life and Work". He was able to reduce manufacturing effort by 60%-90%.
- ✓1936 – Toyota starts its first Kaizen processes in 1936, post its vertical-change from textiles to trucks.
- ✓1970s – Toyota Production System in 1970s and their pillars—just in time and autonomation—first pillars of Lean manufacturing.
- ✓1988 – Coined by John Krafcik, Lean manufacturing comes to the knowledge of the world.

Principles of Lean

- ✓The principles of Lean are also known as Lean 5.
- ✓These 5 principles of Lean are guide to effective Lean implementation.

The 5 Lean principles are:

1. **Identify value –** Specify value from customer's standpoint.
2. **Map the value stream –** Identify all the steps that add value, and eliminate those that don't add value.
3. **Create flow –** Value creating steps should occur in a tight sequence.
4. **Establish pull –** Let customers pull from upstream activity.
5. **Seek perfection –** Once value streams are identified, waste is eliminated, non-value-add are reduced, flow happens, and customer starts pulling; continue until state of perfection is reached.

Key Benefits of Implementing Lean

Key benefits of Lean are summarized below:

- ✓Improved customer service;
- ✓Improved productivity;
- ✓Defect and rework reduction;
- ✓Waste reduction;
- ✓Improved flow;
- ✓Improved lead times; and
- ✓Reduced levels of inventory.

Important: The most important benefit of Lean is to help achieve continuous flow.

Key Benefits of Implementing Lean (Contd.)

- ✓ Typical Lean project benefits summary as below:
  - Productivity: + 25%
  - Scrap levels: - 20%
  - Space: - 40%
  - Delivery: + 26%
  - Stock turns: + 33%

Why Lean before Six Sigma

- ✓A Black Belt should always **check the process for waste** and reduce it before starting the Six Sigma project.
- ✓It is important to first reduce or eliminate the waste in the process before taking on activities to reduce variation.
- ✓Reducing variation without eliminating waste will result in the **waste hindering with the variation reduction approach.**
- ✓Example: Checking the efficiency of an overweight runner running a race of 100 meters is worthless. First, he needs to be Leaned, i.e., all the waste (extra calories) needs to be removed and then the efficiency needs to be measured.

Summary

We have covered the following in this lesson:

- ✓Waste is anything unnecessary in a process and non-value added activities (NVAs) are activities customers aren't willing to pay for.
- ✓By implementing Lean, we can eliminate waste and reduce NVAs.
- ✓The 5 principles of Lean.
- ✓Several key benefits of implementing Lean.
- ✓Why should we implement Lean before Six Sigma?

Section I, Lesson 6

Lean Concepts Explained

Agenda

- ✓Warusa Kagen
- ✓3Ms
- ✓8 Types of Waste (TIMWOODS)
- ✓Mottainai
- ✓HOSHIN KANRI
- ✓TAKT Time
- ✓Cycle Time
- ✓Lead Time
- ✓Production Cycle Efficiency
- ✓Batch Size
- ✓Every Part Every Interval (EPEI)
- ✓EPEI Calculation Spreadsheet
- ✓Batch Size - Assignment
- ✓Crew Size
- ✓Standardized Work In Progress (SWIP)

Warusa Kagen

"For the want of a nail the shoe was lost; For the want of a shoe the horse was lost; For the want of a horse the battle was lost; For the failure of battle the kingdom was lost; ***And all for the want of a horseshoe nail." – Gemba Panta Rei***

Warusa kagen is:

- ✓A condition of badness
- ✓Represents small abnormalities that are undetected
- ✓Need a keen management eye to identify warusa kagen issues

Important: Warusa kagen identifies the gap between how ideal the process should be and how actually it is performing.

Warusa Kagen (Contd.)

- How to deal with warusa kagen?
  - Demand cleanliness at workplace
  - Visual controls
  - Have respect for people
  - Adherence to standards and work procedures
- Warusa kagen conditions are:
  - Muda (Waste)
  - Mura (Unevenness)
  - Muri (Overburden)

3Ms

The 3Ms are warusa kagen conditions that Lean helps in eliminating/reducing.

The 3Ms are:

- ✓Muda – Wasteful work or work that doesn't add value;
- ✓Mura – Unsteady work, work happening irregularly; and
- ✓Muri – Inefficient work.

Important: TIMWOODS, popularly known as 8 Lean wastes, are types of muda.

8 Types of Waste (TIMWOODS)

8 Main types of waste

- ✓Travel
- ✓Inventory
- ✓Motion
- ✓Waiting
- ✓Overproduction
- ✓Overprocessing
- ✓Defects
- ✓Skills

Mottainai

- ✓Mottainai is an exclamatory word, which when used translates to, “Oh! What a waste!”
- ✓This exclamatory word is used with anything unnecessary identified.
- ✓Mottainai refers not only to physical wastes, but also wasted and wasteful efforts and actions, and more importantly time.
- ✓Mottainai has very limited practical significance, but underlines TPS’ commitment and culture when they identify waste.

Hoshin Kanri

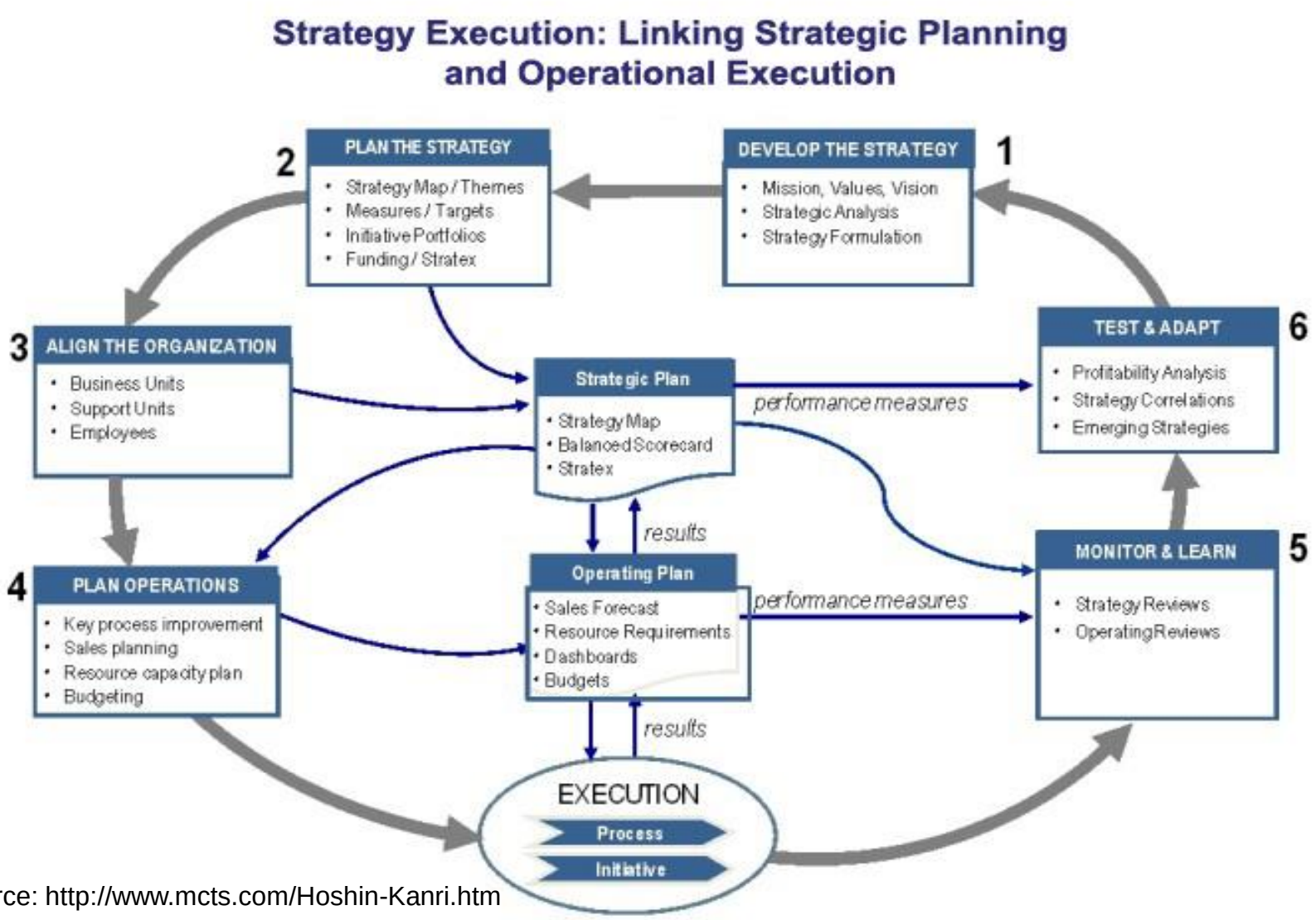
- ✓In Japanese, Hoshin means shining metal and Kanri means management or control.
- ✓Popularized by Dr. Kaoro Ishikawa, it is a strategic management methodology.
- ✓Hoshin kanri helps an organization to:
  - Focus on a shared long term goal;
  - Empowers them to communicate the goal to the leaders;
  - Involve the leaders in planning the goal; and
  - Have the participants in the goal-setting exercise, accountable.

Hoshin Kanri (Contd.)

How to do hoshin kanri ?

- ✓ Set or define annual and medium to long term policy
- ✓ Define the company approach and the quality policy
- ✓ Convert methodological policy to objective policy
- ✓ Identify the composition of policy
- ✓ Identify the type of deployment – Top down or bottom up
- ✓ Target deployment
- ✓ Discussion
- ✓ Finalization and roll out of policy
- ✓ Top management internal audit

Hoshin Kanri (Contd.)



Source: http://www.mcts.com/Hoshin-Kanri.htm

Takt Time

- ✓Takt is an alternative for the German word, taktzeit, which stands for rhythm of music.
- ✓Takt time also sets the required pace of production, in order to meet the customer demand.
- ✓Takt time is the available time for production needed to meet the customer demand.
- ✓Takt time = Available time for production/customer demand.
- ✓Takt time helps in identifying the target of the production line.

Takt Time (Contd.)

- **Example** – A company works for 8 hours, i.e., 480 minutes out of which break time is 30 minutes and meeting time is 30 minutes, and customer needs 100 products. What is the takt time for the production line?
- **Solution –** First, we need to calculate available production time.

Available production time = Scheduled time – Break time – Meeting time

= 480 minutes – 30 minutes – 30 minutes

= 420 minutes

Customer demand = 100 units

TAKT time = 420 minutes/100 unit = 4.2 minutes per unit

- **Interpretation –** The production line needs to manufacture 1 unit every 4.2 minutes to meet the current customer demand.

Cycle Time

- ✓This is the time when actual work happens in the process.
- ✓Cycle time is split into four components:
  - Auto time – Time spent by machines running unattended;
  - Manual time – Time spent in loading, unloading, and adding components during the same process;
  - Delay time – Time spent waiting for operator or other process to finish, or parts or raw material availability; and
  - Machine time – Time spent by machine working on the part.
- ✓In an ideal production process, the cycle time must be as close to the takt time as possible.
- ✓If cycle time < takt time, then possible overproduction and increased inventory levels.
- ✓If cycle time > takt time, then possible waiting for customers.

Lead Time

- ✓Lead time is the time between customer order and delivery of the product.
- ✓For example, delivery of most pizzas from Domino's Pizza is 30 minutes. 30 minutes here is the **lead time (expected)** set by Domino's Pizza for its customers.
- ✓Small order of preexisting items will have a lead time of few hours due to operational push – pull mechanism.
- ✓Larger orders or custom makes will have lead times in weeks/months. For example, a custom made car ordered to make will take at least 6 months to deliver.
- ✓Reducing lead time should be the target, but to do so, you should reduce cycle time, set up time, and wait time. Lead time will automatically get impacted.

Lead Time – Assignment

Problem

With the understanding of all the concepts on time, let us try solving this problem.

- ✓ A customer orders a product on 26th February to the company. The company starts work on 28th February, and completes it by 29th February. It ships the product on 02nd March and the product reaches customer on 5th March.
  - What is the cycle time?
  - What is the throughput time?
  - What is the lead time?

Lead Time – Assignment (Contd.)

Solution

Cycle time = **2 days** (Assuming no set up time and idle time on 28th and 29th February)

Throughput time = **3 days** (Assuming raw materials are assembled on the 27th February and throughput time is time taken to convert raw materials to finished goods)

Lead time = **9 days** (The customer ordered the product on 26th February and received the product on 5th March).

Interpretation

✓If cycle time > takt time, the customer waits longer for his product.

✓Product should have been shipped on the 29th February. Why the delay?

Production Cycle Efficiency

- ✓ Production cycle efficiency is also known as process cycle efficiency (PCE).
- ✓ PCE = (Value added time)/(total time) * 100 %.
- ✓ In other words, PCE shows how much of the total lead time is utilized in doing actual process work.

Note – Actual process work means value-added work.

- ✓ Cycle time is the closest indicator of value-added work.

For example, if the lead time for a product is 20 hours and value added time is 2 hours, the PCE is (2/20) * 100% = 10%.

Only 10% of the overall process lead time is utilized in doing value-added work.

Batch Size

- ✓Traditionally, production models are used to run on EOQ (economic order quantity) and ELS (economic lot sizing).
- ✓Batch size and a related concept, one piece flow, were introduced with TPS and further Lean.
- ✓To calculate batch size, an important metric EPEI needs to be understood completely.
- ✓EPEI stands for every part every interval.

Every Part Every Interval (EPEI)

Situation

Item	Daily demand	Cycle time	Run time	SU time
1.	100	1 min	100 min	20 min
2.	200	1 min	200 min	30 min
3.	300	1 min	300 min	10 min

SU Time = Set up time

min stands for Minutes

EPEI (Contd.)

✓ **Step 1**

- Total available production time = 12 hours = 720 minutes
- Total run time of machines = 100 min + 200 min + 300 min = 600 minutes
- Total time for setup and changeover = 720 minutes – 600 minutes = 120 minutes

✓ **Step 2**

- Actual set up time = 10 minutes + 20 minutes + 30 minutes = 60 minutes

✓ **Step 3**

- EPEI = Actual set up time / total available set up time = 60/120 = 0.5 Days.

✓ **Interpretation –** EPEI in this case is 0.5., i.e., we can do set up every 0.5 day (also, can be interpreted as two setups per day)

EPEI (Contd.)

Benefits of EPEI:

- ✓Reduces lead time to as low as possible;
- ✓Helps identify setup time accurately;
- ✓Easy to calculate;
- ✓Easy to understand how to reduce it; and
- ✓Easy to implement.

Optimal EPEI means:

- ✓We find the optimum number of changeovers to match takt time. This eliminates waste due to waiting or over-production.
- ✓ Levels production.

EPEI Calculation Spreadsheet

	Unit	Quantity	
Number of machines	Number	5	
Working hours for machines	Hours	16	
Daily available capacity	Mins	4800	(Number of machines * Working Hours for machines)
Up time of machines	Percentage	80%	(Factors in leakage, system downtime etc.)
Total up and running time of machines	Mins	3840	(Uptime % * Daily avail capacity)
Available cycle time and changeover time	Mins	3840	
Required cycle time for processing of products	Mins	1600	
Daily changeover time available	Mins	2240	
Num of machines/products applicable for	Mins	13440	(For 6 machines/6 products)
EPEI	Days	9.333333333	(The EPEI is 9.33 days)

Batch Size – Assignment

With the fundamentals on EPEI clear to us, let us find out how to calculate batch size.

- ✓Number of machines – 10
- ✓Cycle time per part – 2 minutes
- ✓Average daily demand – 20
- ✓Work hours – 480 minutes
- ✓Average changeover time – 60 minutes (Once at the end)

Solution

- ✓**Step 1 – Production time needed**
  - Production time needed = No. of machines * cycle time per part * average daily demand

    = 10 * 2 * 20 = 400 minutes
  - Time available for set up = Available production time – production time needed

    = 480 – 400 = 80 minutes

Batch Size – Assignment (Contd.)

✓ **Step 2 – Calculate EPEI**

- EPEI = number of setups possible in the 80 minutes set up time

  = (Average set up time provided)/(Total set up time calculated)

  = 60/80 = 0.75
- Number of machines = 10
- If there are 10 machines, there would be 10 changeovers.
- The number of setups of 0.75 means that only 0.75 changeovers are possible, not 10.
- EPEI is the time required to cycle all the parts.
- Working at 0.75 changeovers per day, it would take 7.5 days to complete all changeovers.

That is,

- **EPEI = 7.5 days**

Batch Size – Assignment (Contd.)

- Batch size = EPEI * Daily demand.
- From the calculation, batch size = 7.5 * 20 = 150.

✓ **Interpretation:** The daily demand is 20, but the batch size is 150. That is over-production.

✓ **How to reduce this batch size?**

- By reducing either cycle time or changeover time.

Batch Size – Assignment (Contd.)

✓Reducing batch size by reducing cycle time.

✓**Reduce cycle time to 1 min** from the existing 2 minutes. Then,

- Production time needed = 10 * 1 * 20 = 200 minutes
- Available time for set up = 480 minutes – 200 minutes = 280 minutes
- Number of set ups possible = 280 minutes/60 minutes = 4.67
- So, the lot size can be reduced from 7.5 days' worth demand to about 2.5 days' worth demand (Almost a 70% reduction in inventory with a 50% reduction in cycle time).

✓Reduction in cycle time → Reduction in EPEI → Reduction in batch size → Reduction in inventory

Batch Size – Assignment (Contd.)

- ✓Reducing batch size by reducing changeover time.
- ✓Reduce changeover time to 30 minutes with no change to the cycle time.
- ✓# of setups = (480 – 400)/30 = 80/30 = 2.67setups
- ✓So, that means with a 50% reduction in changeover time, good 50% reduction in batch size can be achieved.

Important: Batch size indicates inventory levels in the production line.

Crew Size

- ✓Crew size is the number of people needed to man the production line.
- ✓Crew size = Cycle time/Takt time
- ✓**Example:** A product works on a takt of 80 minutes and has production cycle time of 400 minutes. What is the crew size?
- ✓**Solution:**
  - Crew Size = 400/80 = 5
  - 5 staff are needed on the line to ensure takt target is met.

Crew Size – Assignment

- Let us assume that in this case, the manual cycle time is about 240 seconds and Auto cycle time is about 160 seconds.
- Now, 240/80 = 3, i.e. considering only the manual cycle time.
- Therefore, a staff size or crew size of 3 is needed to meet the customer demand, on the assumption that the auto cycle time is running at 160 seconds.
- **Thus the optimal crew size is given by the formula –**

  (Manual cycle time)/TAKT time

Crew Size – Assignment (Contd.)

The manual cycle times are given below:

- ✓Product A – 5 minutes
- ✓Product B – 4 minutes
- ✓Product C – 6 minutes

The daily demand for these products are given below:

- ✓Product A – 30 units
- ✓Product B – 30 units
- ✓Product C – 40 units

Thus, in all a total of 100 units need to be produced in an available time 400 minutes for production. Takt time here is 4 minutes per product. For simplicity reasons, no changeovers for the product are taken.

Crew Size – Assignment (Contd.)

Use weighted average cycle time concept, with the formula = SUMPRODUCT() in Microsoft Excel.

	Cycle Time	Demand
Product A:	5	30
Product B:	6	30
Product C:	4	40
Product D:		
Product E:		
Average:	5	
Weighted Average:	4.90	
Takt Time:	4	
Crew Size Using Average:	1.25	
Crew Size Using Weighted Average:	1.23	

Standardized Work in Progress (SWIP)

Here is an example to understand this. The customer demand is 100 units and the available time is 400 minutes of production, factoring in the breaks.

Takt time = 400/100 = 4 minutes per piece

Assume that the manual labour time per piece is about 2.5 minutes and automatic time is 1.5 minutes,

Total time = 2.5 minutes + 1.5 minutes = 4 minutes

Thus, SWIP = 1

This is the minimum necessary process inventory needed, to maintain **one piece flow.**

The SWIP of 1 means, 1 piece of SWIP is needed per person, or 1 piece of minimum inventory is necessary per person to maintain **one piece flow**.

Summary

In this lesson, we have understood the concepts of:

- ✓Warusa kagen
- ✓3Ms
- ✓8 Waste
- ✓Mottainai
- ✓Hoshin kanri

Also, we have learnt the concepts and calculations of:

- ✓Takt time
- ✓Cycle time
- ✓Lead time
- ✓Production cycle efficiency
- ✓Batch size
- ✓Crew size
- ✓Standardized work in progress (SWIP)

Section I, Lesson 7

Lean Tools Explained

Agenda

- ✓5S
- ✓SMED
- ✓Heijunka
- ✓Genchi Gembutsu
- ✓Value Stream Mapping (VSM)

5S

- ✓ One of the easiest tools to apply in Lean manufacturing.
- ✓ The objective of applying 5S is to maintain a clean workplace.
- ✓ Stands for –
  - Sort (Seiri);
  - Stabilize (Seiton);
  - Sweep (Seiso);
  - Standardize (Seiketsu); and
  - Sustain (Shitsuke).
- ✓ Key benefits of applying 5S:
  - Organized workplace;
  - Quality; and
  - Health and Safety.

Use the 5S audit worksheet to complete 5S. (Provided in toolkit)

5S (Contd.)

Source: http://yaba-jom5s.blogspot.in/2010_07_01_archive.html

5S – Audit Worksheet

5S Evaluation – Production	A High Score is Desirable					
	5	4	3	2	1	Total
Sort - when in doubt, throw it out, delete or archive						
1. Only the current levels of inventory in the area is needed for the work at hand.						
2. Only the necessary items to perform the work at hand are located in the area.						
3. All tools, fixtures, and jigs in the area are used on a regular basis.						
4. All announcements are arranged in a straight and neat manner.						
5. Your general impression should tell you this is the best you have seen for a manufacturing environment.						
Straighten - decide and organize where to keep necessary items						
1. Machines, benches, etc., are arranged in a logical & neat fashion to promote a smooth product flow through the work area.						
2. Lines on the floor clearly mark aisles, walkways, work areas, storage locations, and danger areas.						
3. Only current labeled documents and binders necessary to do the work are stored at workstations.						
4. Tools, gages, and fixtures are arranged neatly and stored, kept clean and free of any risk from damage.						
5. Equipment is properly maintained and labeled. Critical points for daily maintenance checks are clearly marked.						
Shine - perform a thorough cleaning						
1. All floors are clean and free of debris, oil, and dirt. Cleaning of floors is done routinely and at appropriate predetermined intervals.						
2. Routine cleaning of machines is apparent, there is no oil, chips, scrap laying on work surfaces. Glass view windows, guards, deflectors are clean & in place.						
3. All equipment in the area is cleaned on a regular basis.						
4. When unexpected delays occur, operators habitually & automatically sweep floors & wipe equipment.						
5. Where applicable, FOD prevention procedures are enforced. All loose items removed before entering FOD prevention area. Shadow boxes kept clean.						
Standardize - incorporate cleaning procedures into the daily work						
1. Display boards are present in each production work area and accessible to all personnel in the area.						
2. 5S audits are performed in each work area at least monthly, results are shared with all workers, and goals for new levels set with action items.						
3. PPE notices are posted in every area and all employees are wearing the required PPE's.						
4. It is obvious that workers who perform similar duties, use standard methods to achieve consistent results.						
5. Methods are reviewed on a regular basis, and as new methods are developed, they are quickly documented and adopted by others.						
Sustain - management and leadership to motivate and sustain						
1. Employees are adequately deployed to keep equipment operating properly. A Preventive Maintenance program is in place and functions at a high level.						
2. Each area of the operation, inside and out, falls under the responsibility of a manager with 5S auditing and assignment authority.						
3. All documents and binders are clearly labeled as to their contents. Responsibility for control & revisions is clear. Nothing is unlabeled.						
4. Responsible manager/staff person visits each work area on a regular basis and provides feedback on 5S efforts and results.						
5. Disciplined controls to assure each of above items is maintained at highest level. There is a sense of responsibility by all employees to maintain systems.						

SMED

- ✓SMED = Single minute exchange of die.
- ✓Losses due to setup is a major reason for extension in Lead times.
- ✓Reducing set up time is one of the key objectives for any process cycle.
- ✓The idea of SMED is to reduce complications in the machines and make them simpler and faster to setup.
- ✓Set up time is classified into internal and external set up time.
  - External set up is one that can be completed while machine is in operation.
  - Internal set up requires machine shutdown for operation.
- ✓Goal – 1) Change all internal setups to external setups; 2) Reduce length of internal setups if unavoidable; and 3) Reduce lengths of external setups.

SMED (Contd.)

Benefits of SMED

- ✓Reduced set up time
- ✓Higher efficiencies
- ✓Increased capacity
- ✓Reduced WIP's
- ✓Lower batch sizes
- ✓Increased safety
- ✓Increased flexibility
- ✓Reduction of waiting
- ✓Operator's preference
- ✓Reduced inventory

Important: SMED is an important technique, which is adopted in most Lean Implementations and one that starts with study of set up time.

Heijunka

- ✓ Heijunka is a Japanese word, which means “Leveling”.
- ✓ Heijunka’s concept also known as Heijunka Box ensures volatile customer demands are leveled.
- ✓ Heijunka principle helps in reducing muda.
- ✓ The main goal of Heijunka is to produce intermediate goods at a ready constant rate, by reducing fluctuations in the production process.
- ✓ In scenarios of constant demand, Leveling is easy. In scenarios where demand fluctuates, Leveling can be done per demand leveling or production leveling.

Step 1 in Leveling production is to assemble a mix of models in each batch, and Step 2 is to reduce Batch Size.

Heijunka – An Example

A company workshop works for 8 hours a day, 5 days a week, and 20 days a month. It manufactures a product in one hour. Below is the average market demand:

A	B	C	D	E	F	Total
28	60	18	18	10	6	140

Assume changeovers and set ups to be for one hour every day.

A traditional planning model will manufacture 28 products of A in 1 hour slots, and then 60 products and so on.

Per Heijunka planning, the batches would have a mix of all the models and with a reduction in batch size, lead time can be reduced by up to 45%.

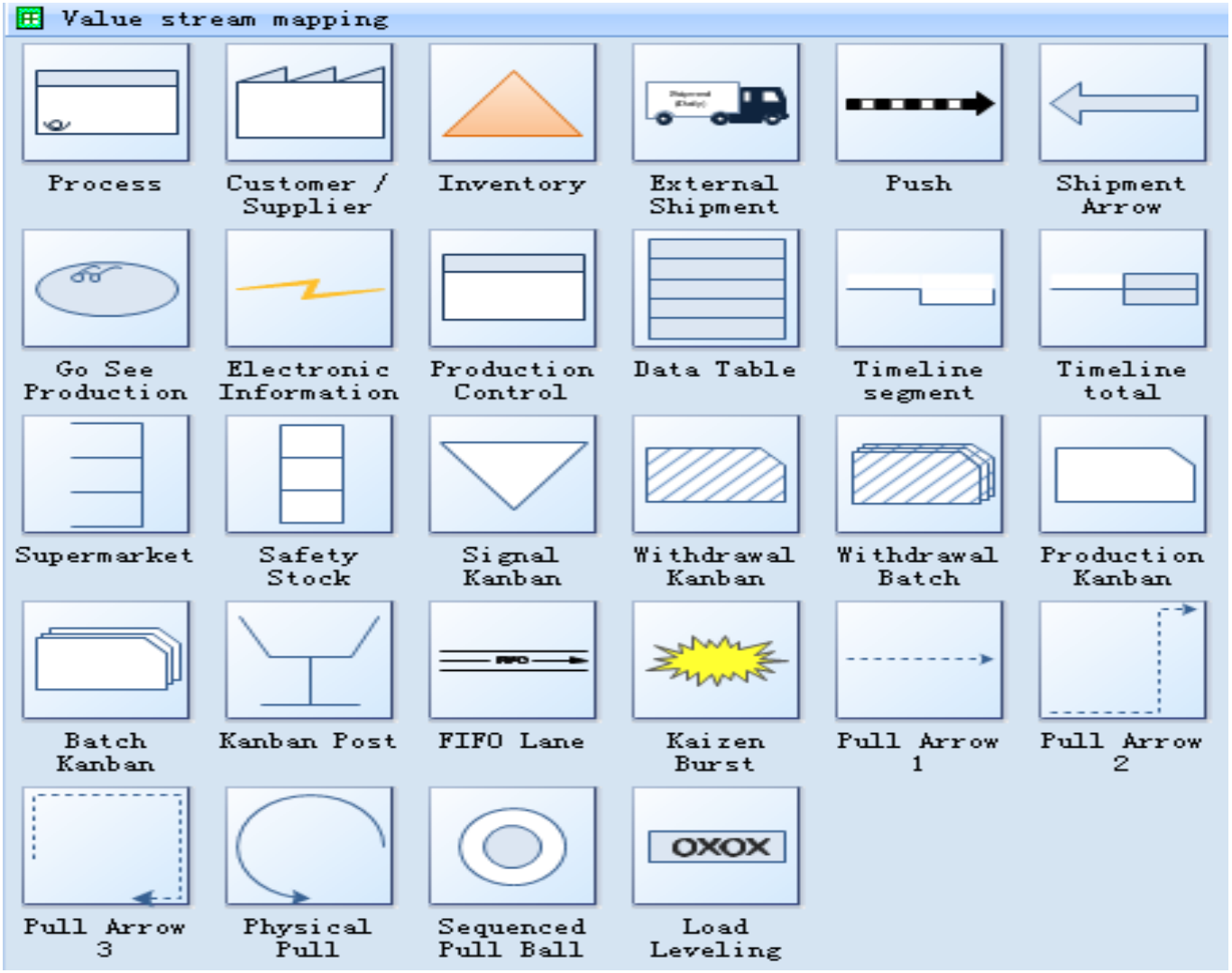
Genchi Genbutsu

- Genchi Genbutsu (sometimes also spelled as Genchi Gembutsu) means "go and see."
- Genchi Genbutsu suggests that in order to truly understand a situation one needs to go to "gemba" or visit the shop floor where the real work is done.
- This is also called as the Heart of Lean, as by doing Genchi Genbutsu on the gemba (shop floor), the management can identify the key issues (visual as well as hidden).
- Genchi Genbutsu in simple words is a management activity, with no statistical connotations attached to it.
- The objective is to enforce the management to skip out of their cabins and regularly visit the gemba (shop floor) to inspect the problems.
- If the problem exists on the shop floor then it needs to be understood and solved at the shop floor.
- Genchi Genbutsu is, therefore, a key approach in problem solving.

Value Stream Mapping (VSM)

- ✓Value stream mapping (VSM) is a very powerful tool that helps in identifying the wastes and moving from the current state process to a future state process.
- ✓VSM must always be preceded by rigorous Genchi Genbutsu which helps in collection of relevant data for the process.
- ✓It is important to remember that the process needs to be mapped from a customer's point of view and not from a process point of view.
- ✓Step 1 is to create a current state map identifying all wastes and Step 2 is to create a future state map.

VSM Symbols



Value Stream Mapping (Contd.)

Important data metrics to be collected before drawing a value stream map

- ✓Cycle time (time taken to make one product)
- ✓Changeover time (from last good piece to next)
- ✓Uptime (on-demand machine utilization)
- ✓Number of operators
- ✓Net available working time
- ✓Scrap rate
- ✓Pack size/pallet sizes
- ✓Inventory
- ✓Yield

Important: Any data that contributes to the product flow or adds to the cost of the process should be collected by Genchi Genbutsu

Value Stream Mapping (Contd.)

Key steps to do value stream mapping (While reading this, please follow facilitator instruction on how to draw a value stream map).

1. List all of the steps in a process from beginning to end and create a diagram with a box for every step, in sequence.
2. Calculate the time currently required to complete each step of the process, and add that time to the box.
3. Add the time in each box to yield the total cycle time.
4. Identify NVA steps. NVA steps include: inspection, test, rework, set-up, inventory buffers, product movement other than customer delivery - any activity that does not improve the form, fit, or function of the product on the first pass through the process.
5. Move the boxes representing NVA steps to the right of the value-adding steps.
6. Add the time in each of the NVA steps to yield the NVA cycle time. This is the waste that could be eliminated if only value-added steps were performed.

Value Stream Mapping (Contd.)

7. Add the time in each of the value-added process to yield the value-added cycle time.
8. Calculate the percentage of the total cycle time that is a function of NVA steps. A pie chart can be constructed for this purpose.
9. Identify the target cycle time per business discussions.
10. Diagram the target process and determine the total target cycle time.
11. Analyse the NVA steps to identify actions to reduce or eliminate these operations. Some NVA Steps may be necessary for the business.
12. Analyse the Value-Added steps to identify improvement opportunities and implement actions to reduce the cycle time.
13. Diagram the improved process, compare to the target process, and identify gaps for further improvement actions, in an on-going cycle, until the target is achieved.

Please use the tool, VSM template, provided as part of the toolkit to construct VSM. For further instructions, refer to the Generic VSM worksheet in the toolkit.

Summary

In this lesson, learnt how to use:

- ✓5S
- ✓ SMED
- ✓Heijunka
- ✓Genchi Genbutsu
- ✓Construct value stream map for a process

Important: Refer to the worksheet Lean glossary in the toolkit provided for understanding the tools, concepts, and their applications.

Quiz

1. Which of the below represents a major stumbling block for a change effort?

a) Refusal to change

b) Not deciding whether to change

c) Postponing change

d) Excuses for change

2. Which of the roles below a Black Belt is least expected to assume?

a) Data collection

b) Data analysis

c) Suggesting improvements

d) Project funding

Quiz

3. Which of the tools below will you use to analyze factors of change?

a) Stakeholder analysis

b) Motivational analysis

c) Force field analysis

d) Employee HR analysis

4. Which of these is one of the major reasons of applying Lean?

a) Reduces cycle time

b) Reduces lead time

c) Achieves continuous flow

d) Increases productivity

Quiz

5. Which of the below mentioned concepts helps you determine inventory levels?

a) Demand size

b) Batch size

c) Volume

d) Production utilization

6. Which of the following directly helps you determine Batch Size?

a) Set up time

b) Changeover time

c) Cycle time

d) EPEI

Answers

1. b) Organizations have to focus really hard to overcome this section of people.
2. d) A Black Belt can assume the other three roles as per the need, but ideally should not get into project funding.
3. c) Force field analysis helps you analyze factors of change by looking at both the side – the process change needs and the people change aspects.
4. c) One of the principal benefits of applying Lean is achieving continuous flow. All others are byproducts.
5. b) Batch size helps you in determining inventory levels.
6. d) EPEI, or Every Part Every Interval is the key metric helpful in determining batch size.

Thank You