Lean Production Part III

Course: Production Management and Logistic Systems [10592713]

Economia e management (Latina Campus)
AA 2024-2025 | Prof. Alessandro Pietrogiacomi

SAPIENZA
UNIVERSITÀ DI ROMA

Latina April 2, 2025

Lesson Plan for Tuesday, April 2

Overview of the lesson, and educational objectives,

Topic: **Reducing Production Timelines and Improving Quality.**

Part III Lean Production

Time: **10:00–13:00**

Duration**: 3 hours**

Learning Objectives

By the end of this lesson, students will be able to:

- Understand the principles Flow and taxt time, 5 S and visualization management and techniques of root cause analysis

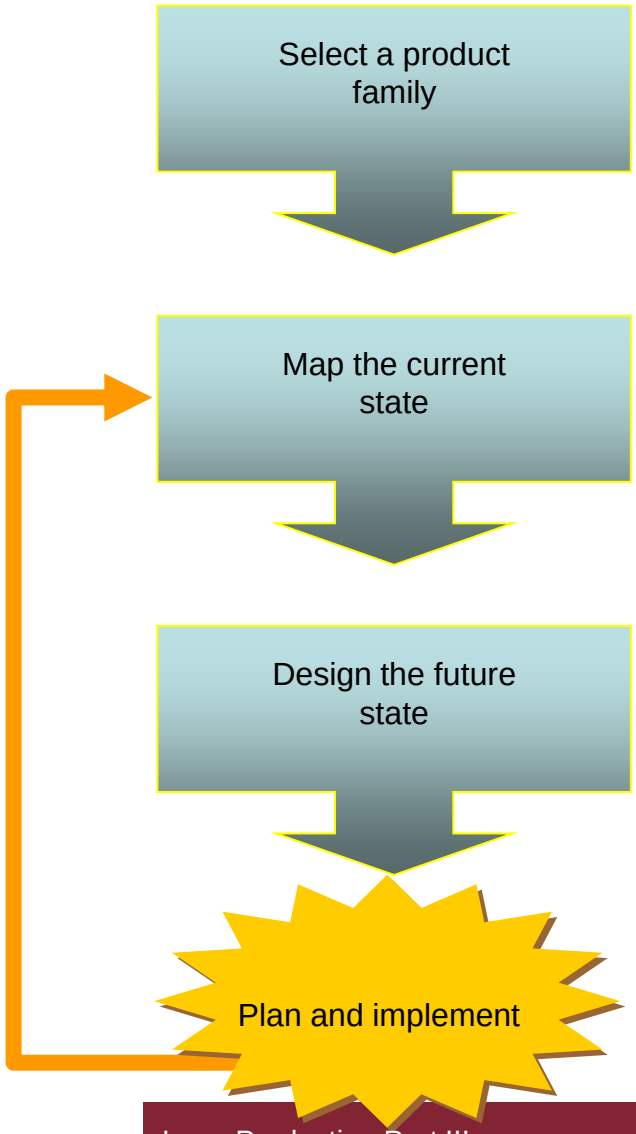
Lesson Outline

1. Material Information Flow Analysis and Takt time (30 minutes)
2. Workplace organization and visual management (30 minutes)
3. Benefits & Impact (45 minutes)
4. Application (45 minutes)
5. Recap, Q&A and Homework Assignment (15 minutes)

Introduction

- Welcome students and recap the previous session (Introduction to Lean Production).

Steps of value-stream mapping



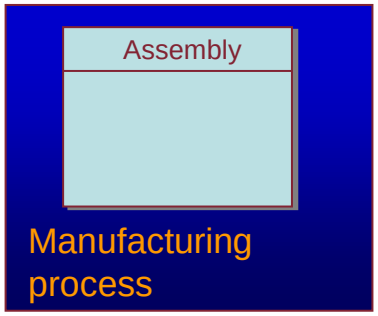
- **Focus on the production of a single product**
  - **Beginning to end**

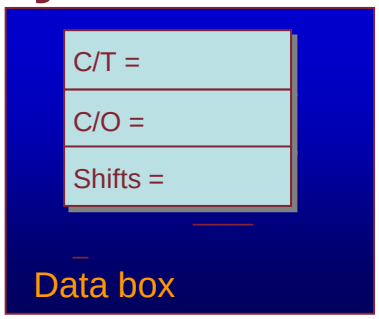
- **Develop an understanding of what happens today**
  - **Information**
  - **Material**
  - **Interactions**

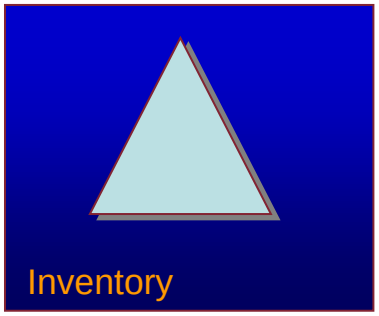
- **Design a lean value stream**
  - **Creates vision for what/where you want to be**
  - **Enables implementation**

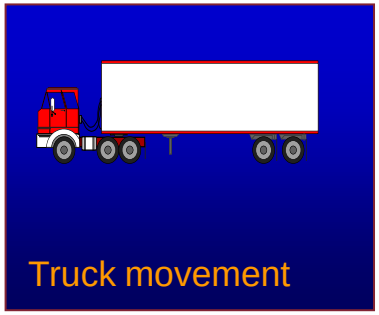
- **Create an implementation plan to achieve Future State design**

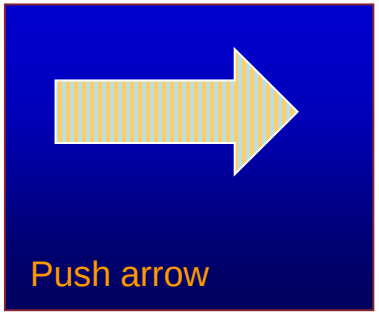
Value-stream mapping – physical flow icons

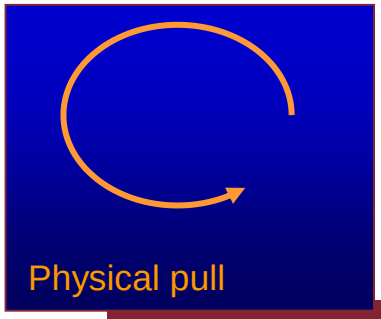




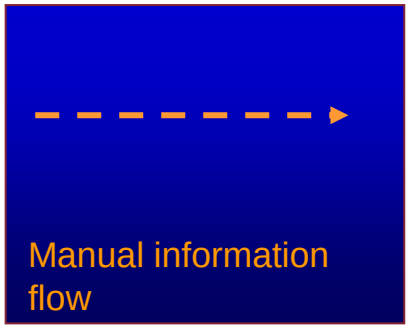


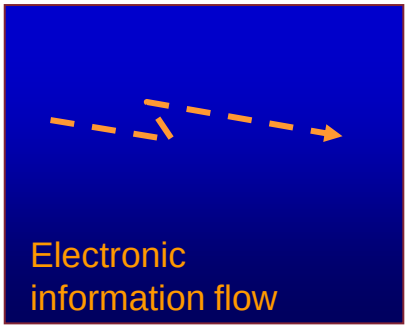


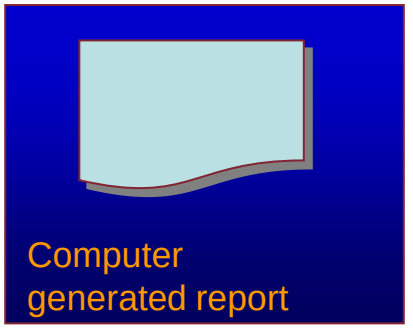


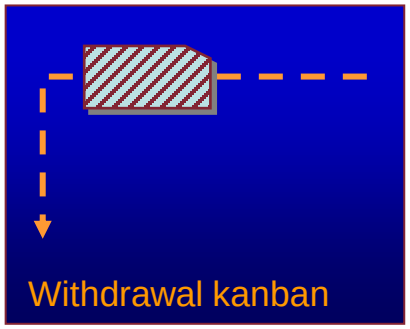


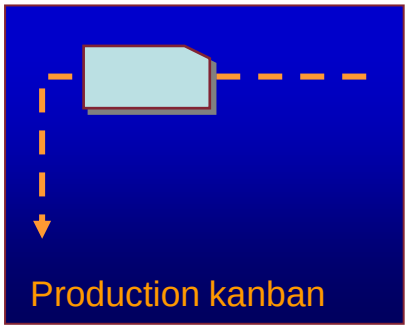
Value-stream mapping – information flow and other icons

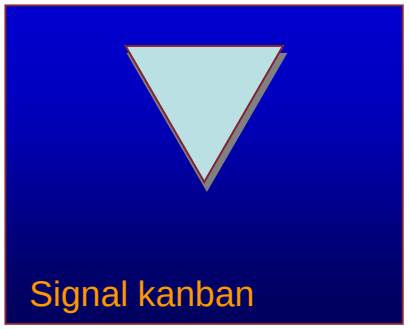


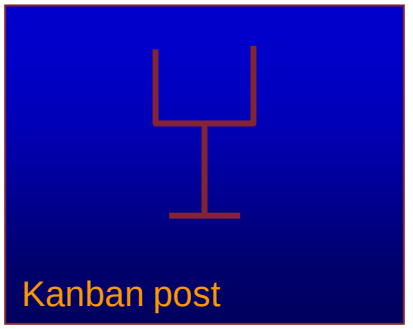


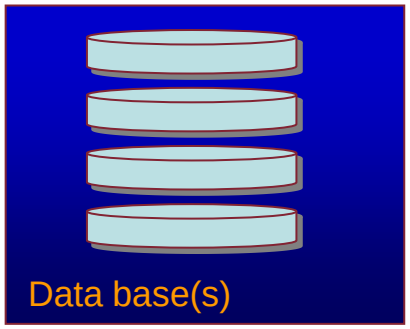




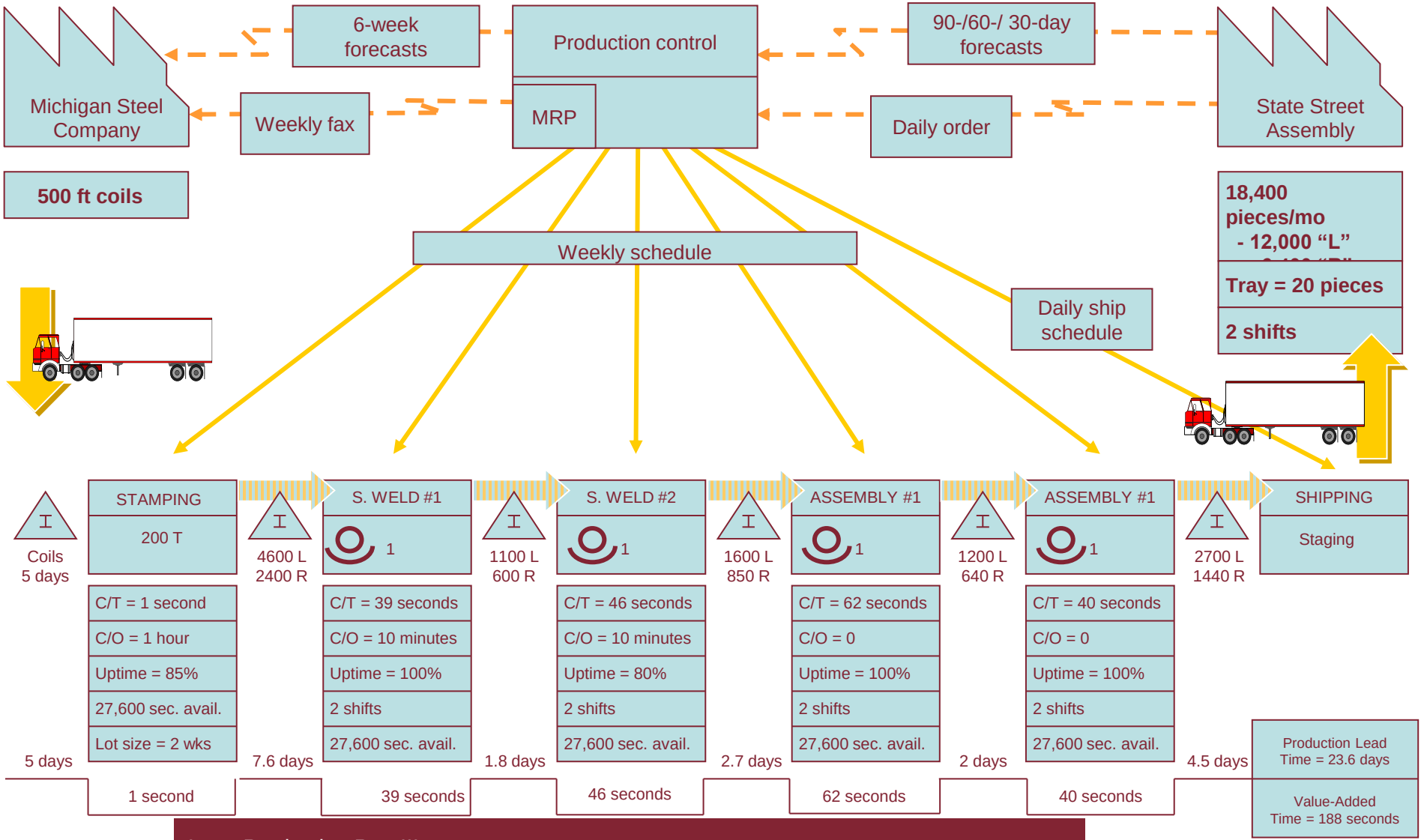




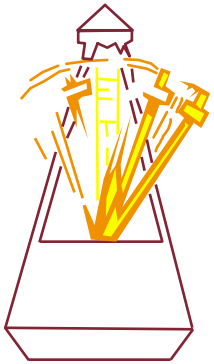




Current state map



Takt time definition and calculation



Takt time

Definition

$$\textit{Takt}\text{ time} = \frac{\text{Total production time available}}{\text{Total customer demand}}$$

- Only scheduled allowances are deducted from available time:
  - Breaks, Lunch, Team meetings
- Never include unscheduled items such as:
  - Changeovers, Staffing availability, Breakdowns on equipment

Calculation

Customer demand:	**642 units per shift**
Total shift time:	**8.5 hours (510 minutes)**
Total time available:	**510 minutes - 50 minutes = 460 minutes**

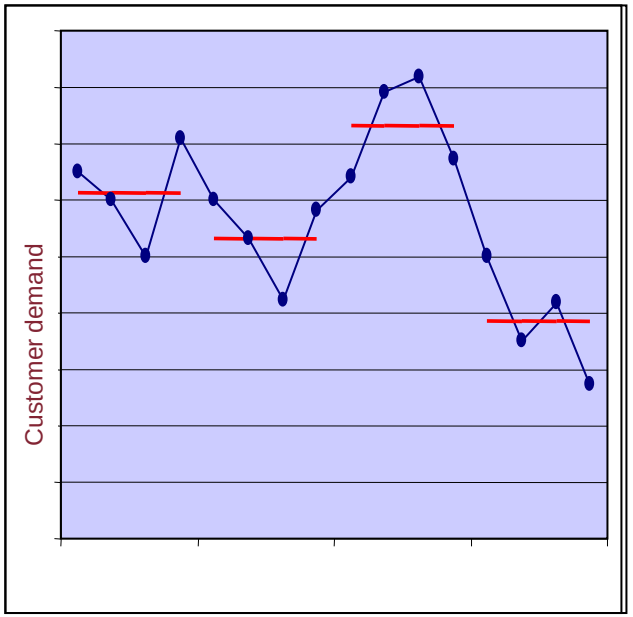
$$\textbf{\textit{Takt} time} = \frac{\textbf{460 minutes x 60 seconds}}{\textbf{642 units}} = \textbf{43 seconds}$$

Takt time – fluctuating customer demand

Takt time must be applied in the real world, where process cycle times and takt times vary due to fluctuating customer demand

Takt time changes according to customer demand

- **Customer demand can vary due to**
  - **Seasonal products**
  - **Poor scheduling or communication**
- **Constantly changing the *takt* time can be counter- productive**
- ***Takt* time should be based on the average customer demand over the shortest time period (e.g., week, month, or others as appropriate)**



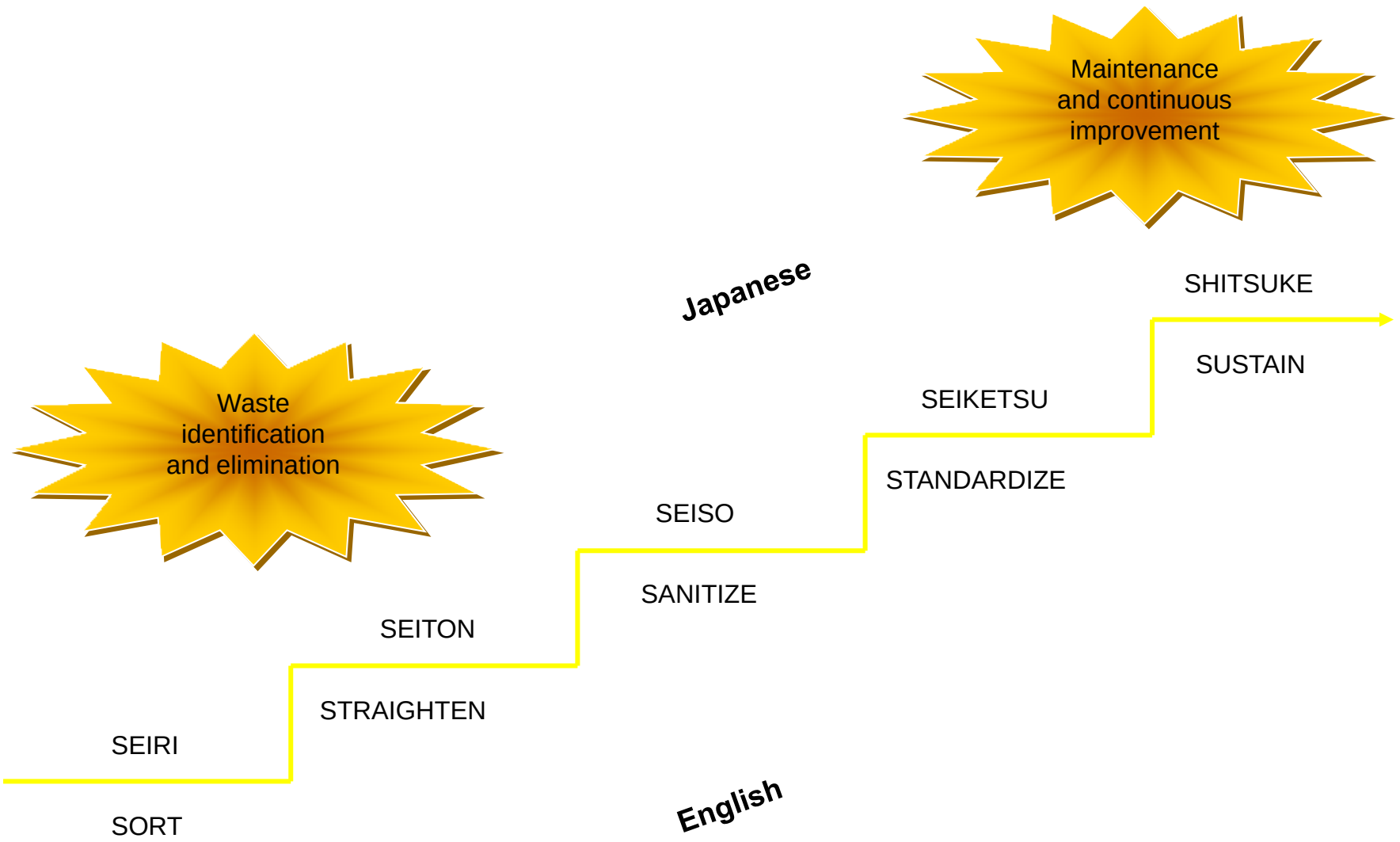
Takt time based upon monthly customer demand

5S – workplace organization

This session will:

- **Defines the elements of 5S**
- **Discuss the objectives of 5S**
- **Present the benefits of 5S - Workplace Organization**
- **Define the steps of 5S application**
- **Answer frequently asked questions about 5S**

Translation of the 5 steps of 5S



Definition of 5S

Sort	Straighten	Sanitize	Standardize	Sustain
• Eliminate all non-essential tools, materials from the workplace	• Organize all necessary tools, materials • Assign an optimal area in the workplace	• Regularly clean the workplace and equipment	• Develop standard procedures and checklists to maintain an orderly, clean, and functional work area	• Implement systems to monitor and maintain to ensure the workplace is improved and 5S becomes part of the culture

Example of 5S – cockpit of an airplane

	Sort	Straighten	Sanitize	Standardize	Sustain
Application	• Only items required to fly the plane are present	• Most important controls are located closest to the pilot, e.g., rudder controls • Controls utilize lights and colors	• All equip-ment is in good working condition • Cockpit is free of dirt and garbage • Clean wind-shield and control panel	• Pilots must fill out check-lists prior to every flight	• Cockpit is inspected regularly by pilots, flight attendants, and main-tenance personnel

5S – workplace organization

Objectives

Background & Introduction

Benefits & Impact
- **Objectives of 5S**
- **Benefits of 5S - Workplace Organization**

Application

Visual management examples

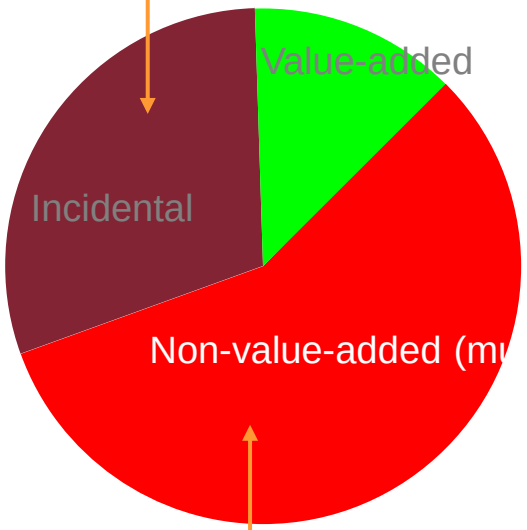
5S objectives

The implementation of the 5S program in a workplace involves not only an initial improvement of a given area, but, more importantly, it involves the creation of a disciplined system to maintain the improved condition over time

- **5S creates a foundation to build stability**
- **5S is key for building a successful continuous improvement environment**

Effects of a 5S program

Improves incidental activities by decreasing operator movements through improved layout of tools/equipment



Eliminates non-value-added activities (e.g., searching for tools) by clearly identifying useful materials and then organizing those items and positioning them in their optimum locations

Sort
- Reduces work-flow problems
- Improves workplace communication
- Improves quality
- Increases productivity

Straighten
- Eliminates searching

Sanitize
- Relieves stress and strain – when something needs to be used, it is in good working order

Standardize
- Maintains first 3 steps
- Establishes daily habit

Sustain
- Ensures continued elimination of waste

5S - workplace organization benefits

Cultural

- Creates an awareness of 5S principles
- Develops an understanding in the organization of the connection between 5S and workplace efficiency
- Completely cleans and organizes a “model area” as the start of ongoing 5S improvement activities
- Develops standard procedures for 5S maintenance and a system to enforce them
- Improves morale and increases worker involvement levels

Operational

- Reduces cost
- Improves operating conditions
- Reduces equipment operation errors
- Improves process reliability
- Promotes safety
- Increases equipment availability
- Improves customer satisfaction

Continuous Improvement

- Increased safety
- Improved work environment
- Greater visibility
- Higher performance

5S – workplace organization

Objectives

Background & Introduction

Benefits & Impact

Application

- **Step 1: Sort**
- **Step 2: Straighten**
- **Step 3: Sanitize**
- **Step 4: Standardize**
- **Step 5: Sustain**

Visual management examples

Identify examples

EXAMPLE

Identify

- **Clear identification of personnel, areas, and equipment helps eliminate confusion on the shop floor**

Photos of cell members

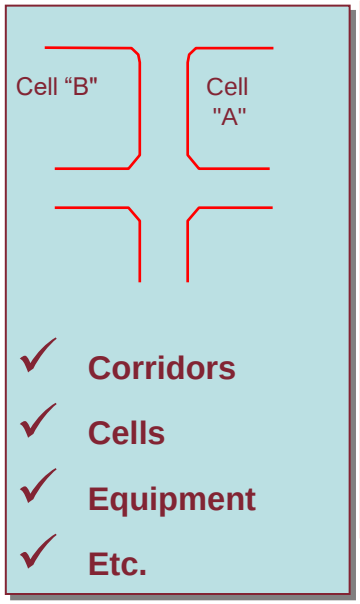
Cell identification

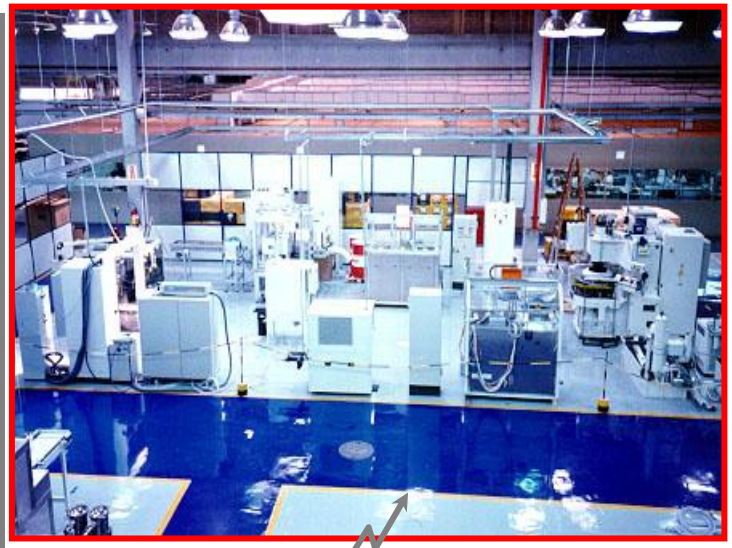
EXAMPLE

Location examples

Mark areas

- Subdividing areas according to production segment is important for the clear definition of managerial responsibility
- Once the layout has been defined, the floor should be marked so that zones of responsibility may be clearly understood, as well as possible anomalies





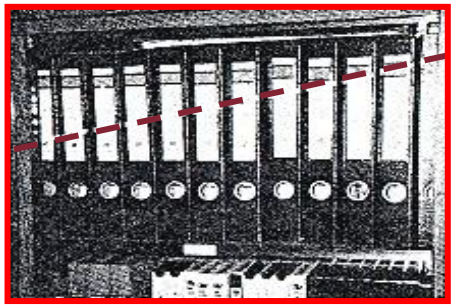
Mark cell boundaries

Delimit equipment with arrows indicating the production flow

Location examples (continued)

Tags and shadows

- All auxiliary material must be tagged, along with their storage location, so that they will always be put back in the same place. Using colors can help
- Shadow diagrams can also help to assure items are returned properly



Reference line!

EXAMPLE file storage

Setup cart

LOCATION EXAMPLES (CONTINUED)

Specify exact location

- The clear marking of location for portable items helps to assure the items will stay in their optimum positions

Waste bin

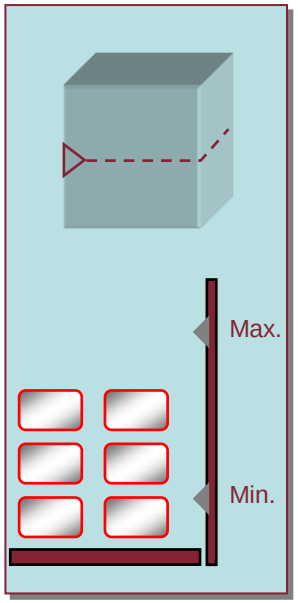
Planter

23

Status examples

Define level and communicate production

- Inventory levels must be defined in a manner that is consistent with the manufacturing system. When levels are lower new production must start; levels above maximum mean excess production
- Actual production and target levels should be clearly communicated, assuring all employees when they are ahead or behind in schedule



Measure levels with colors

Follow cell production in real time

Status examples (continued)

Use of kanban

- The use of kanban can communicate inventory position and customer needs, assuring the correct production decisions are made

A “Heyjunka box” indicates customer needs (quantity, time, and sequence)

A triangular “Kanban”

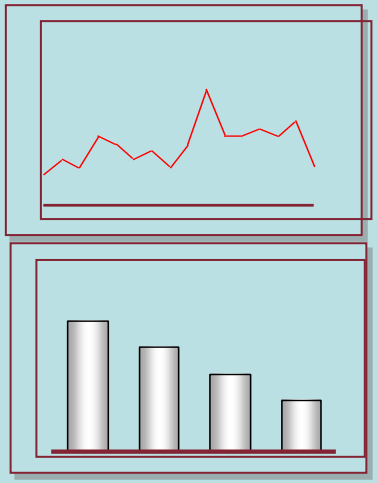
A “Ping-pong Kanban” using FIFO also indicates criticality

Performance example

Indicator charts

- Live and continuous exposition of performance indicators, can be used to assure that the results of actions taken may be clearly understood, as well as the need to tackle any problems that may be out of control

Production indicator



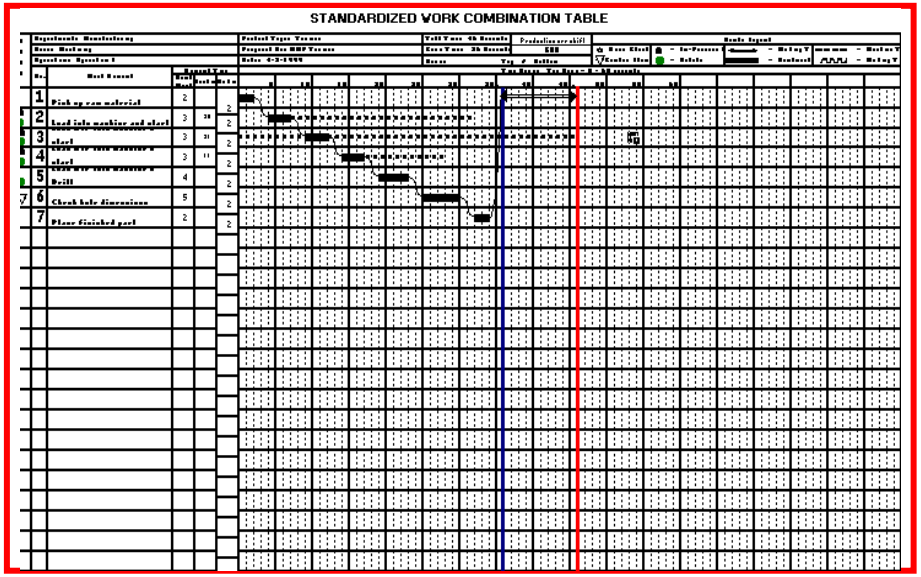
- ✓ **Production level**
- ✓ **Quality**
- ✓ **OEE**
- ✓ **Productivity**
- ✓ **Improvement actions**
- ✓ **Etc.**

EXAMPLE

Standard process examples

Process definition

- Standardized operations displays assure the communication of the best process to all
- Visual displays of project plans assure that all critical personnel are “on the same page”



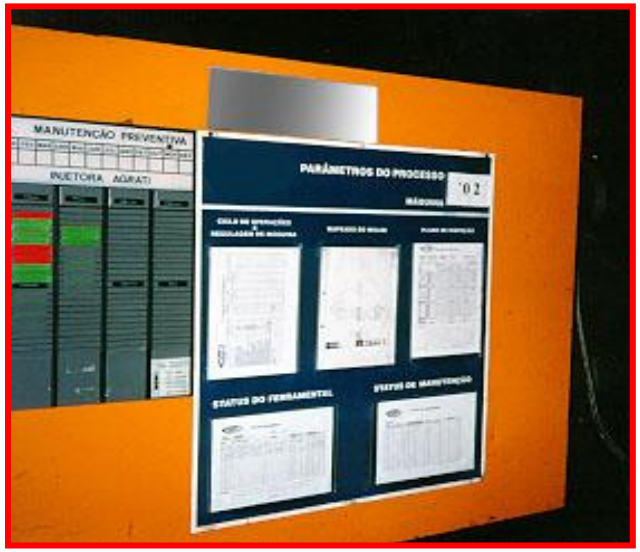
"Gantt" chart for a start-up

EXAMPLE

Standard process examples (continued)

Technical specifications

- Clear display of parameters and technical information eliminates ambiguity and assures that the shop floor has ready access to required knowledge



Process parameters on the front panel of the equipment

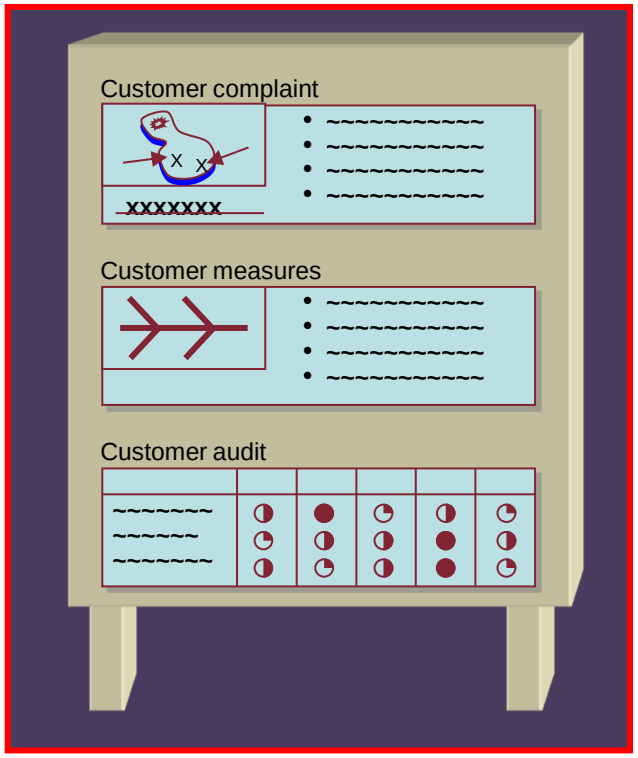
EXAMPLE

Improvement examples

Improvement displays

- The display of continuous improvement efforts assures that problem solving knowledge is disseminated, and it assures that improvement efforts are recognized by all

Combining indicators and “Fishbone” for problem resolution



Customer information

Shop floor problem solving

- Objectives
- Background & Introduction
- Benefits
- Application

Shop floor problem solving

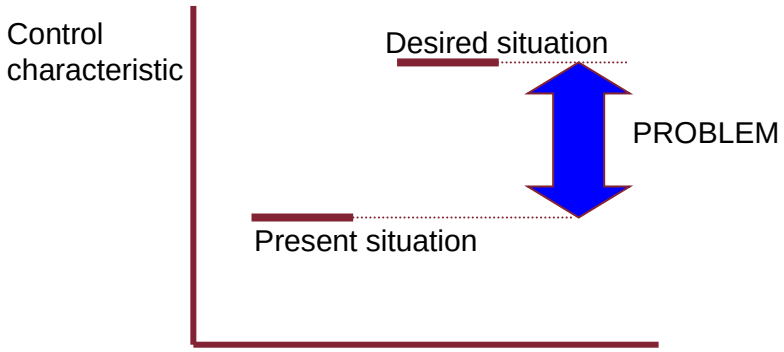
This session will:

- **Define structured problem solving**
- **Discuss the goals of root cause analysis**
- **Illustrate the benefits of root causes analysis**
- **Describe step to accomplish for a correct root cause analysis**

Definition of structured problem solving

- While the theoretical approach of problem solving is effective during basic laboratory research (deductive method) the structured problem solving approach (inductive method) is the only effective way of solving workplace or work-related problems

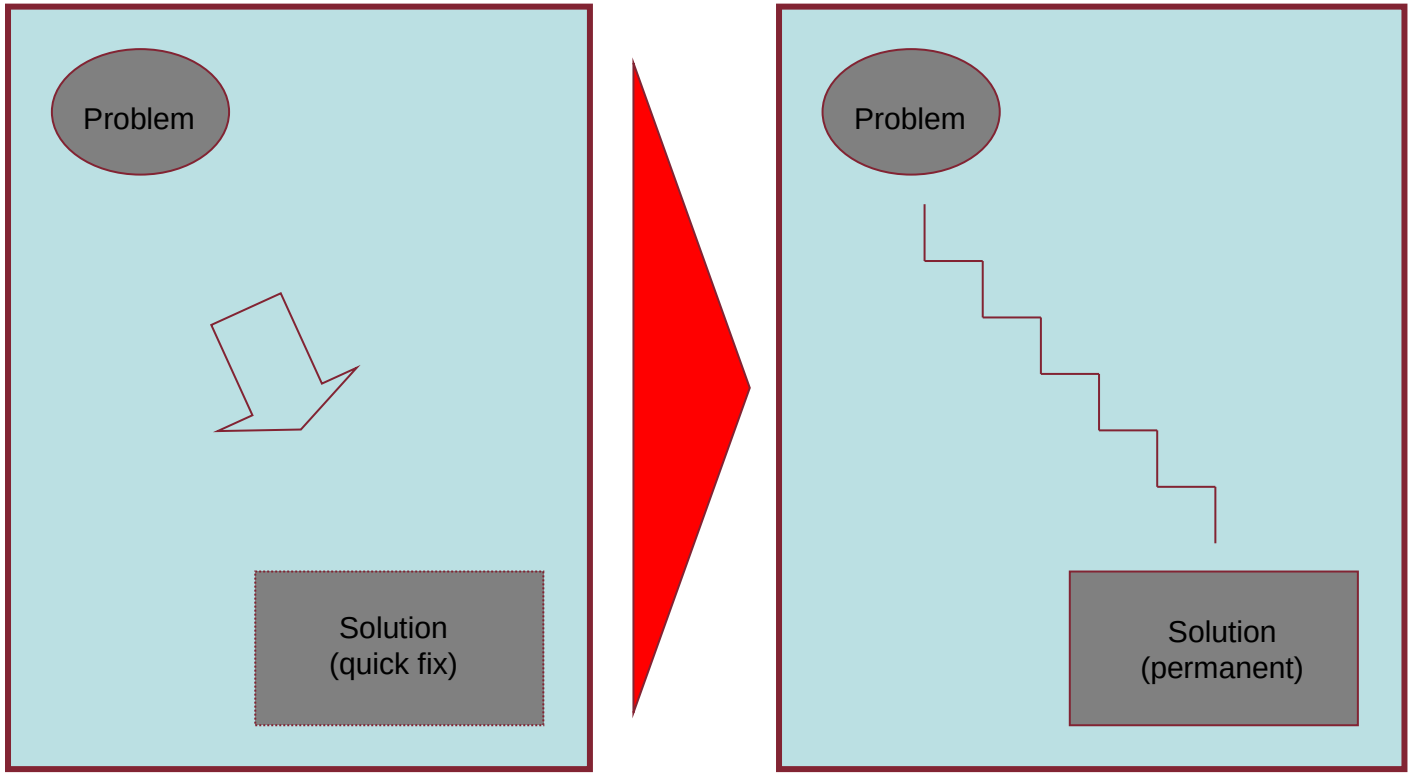
- Structured problem solving defines a problem as ...
- the gap between the present situation and the ideal situation



The structured problem solving approach is a method of solving problems rationally, effectively and efficiently by using a 6-step process, the 7 QC tools and other tools for analysis and idea generation

Traditional approach vs. Structured problem solving

Rather than jumping to “quick fixes,” structured problem solving uncovers root causes to find the right countermeasures for a long-term solution



Tips for a successful shop floor problem solving

Common pitfalls

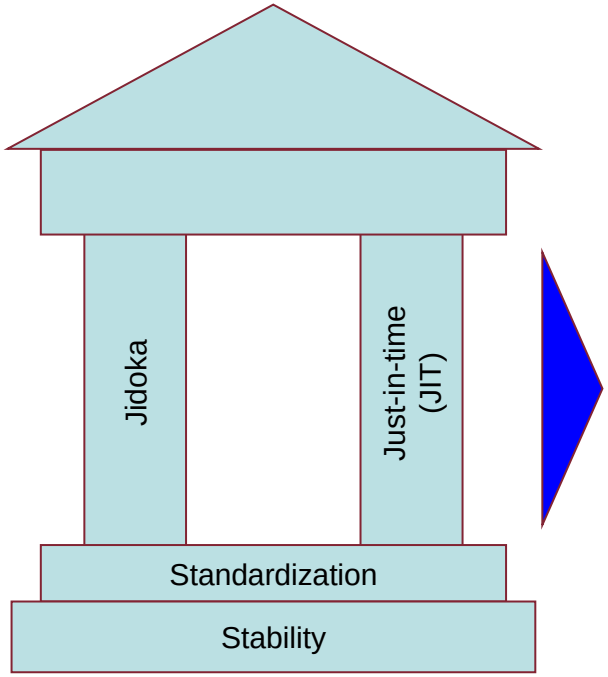
- Fire-fighting instead of long-term countermeasures
- No perseverance and jumping to solutions instead of investing time in thorough analysis
- Working without management support for unpopular ideas and solutions
- Attempting to solve problems without involving the right team of experts
- Failing to set targets and document the process
- Failing to follow up because the next (more important) problem is already there. So some problems become "normal" or "chronic"

Condition for successful problem solving

- Understanding the structured step-by-step quality improvement approach and the benefits of combining short-term countermeasures and reasoned long-term countermeasures
- Providing the necessary resources for an in-depth analysis and conscientious implementation of countermeasures
- Paying attention to the team's progress by intensive communication and using visual management during the whole project
- Ensuring that problem solving teams have the support of a management godfather who helps in difficult situations and clears the way when obstacles occur
- Making available sufficient time for team-meetings, tests of countermeasures, and communication

Function of structured shop floor problem solving in supporting the lean production system

Structured problem solving stands in the tradition of TQC as a comprehensive framework of companywide improvement activities that support the lean production system



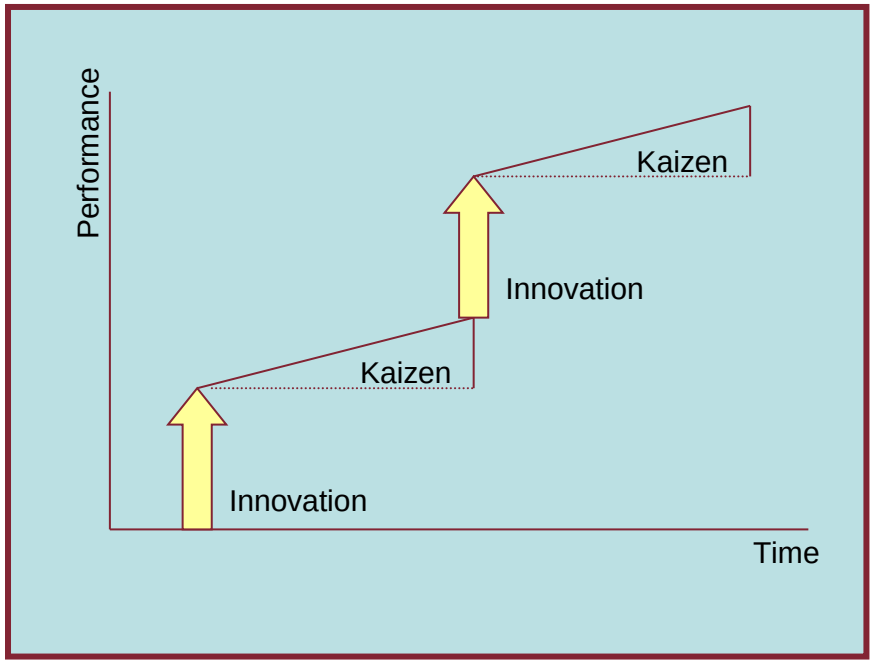
"TQC is not a fast-acting drug like penicillin but a slow-acting herbal remedy that will gradually improve a company's constitution if taken over a long period"

(Dr. Kaoru Ishikawa)

Lean production framework

Continuous improvement and structured shopfloor problem solving

A true lean production system incorporates the ability to improve performance continuously



Continuous improvement (kaizen) is a necessary addition to technological improvements or investments (innovation)

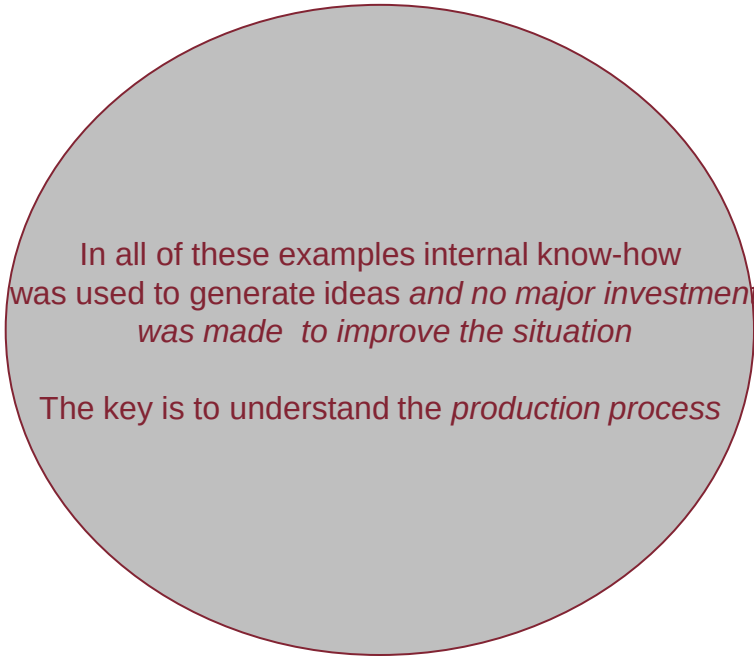
Continuous improvement is not incidental, but often based on team-based problem solving that gets its power from using a systematic method and simple tools

Examples for areas of structured shop floor problem solving

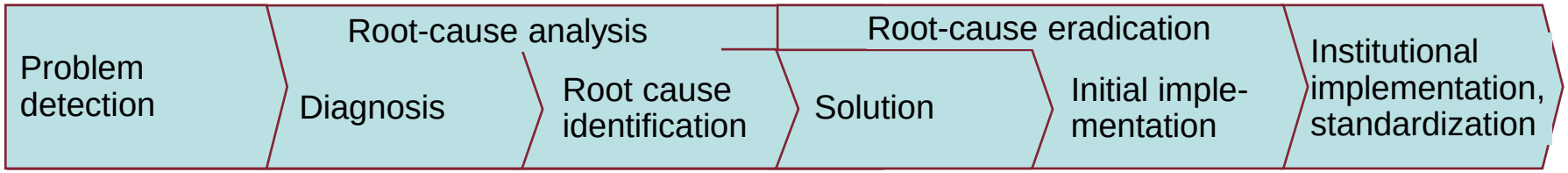
Structured problem solving is the right approach in a lot of cases where improvement cannot be "bought" from the outside but internal resources could be brought together to analyze the situation, gather data, and decide the right countermeasures

Quality improvement is one of the most often mentioned subjects of structured problem solving; there are many areas of use:

- Quality improvement: reducing the number of reworked units in the final assembly of medical devices
- Cost improvement: reducing oil consumption of a mill in a steel plant
- Service improvement: shortening customer waiting time for overhaul of construction equipment
- Delivery performance improvement: achieving nearly 100% on-time-delivery and 50% lead time reduction in the production of customized aluminum containers



Problem detection



Main steps

Problem detection	Diagnosis	Root cause identification	Solution	Initial imple-mentation	Institutional implementation, standardization
• Precise description of problem/defect – Drawings – Photos – Sketches – ... • Localization of the problem (substation, ...) • Detailed description of occurrence modalities – Video – Description of dynamic – .... • Root cause hypotheses	• Systematic investigation to cover all possible causes major and root causes (complete defect tree, fishbone diagram, ...) • Documentation of cause hypotheses and interim solutions	• Reproducible evidence (through simulation of defect/ solution) • Confirmation of root causes	• Implementation plan for selected solution) • Test results or model trials, costs, time needed for possible solutions	• Solution implemented for root cause • Verification of defect eradication	• Defects, root causes, and corrective actions documented • Standards derived, documented, and communicated

Problem detection - Repetitive stops caused by bad interactions between equipment and packaging materials

Sequence of facts occurred at Line 24 — **Total time lost = 10’**

Cardboard box becomes stuck with equipment devices

Comments

- **Line needs to be stopped**
- **Risks of further damages to equipment devices**

Products and residual fragments of cardboard must be carefully removed by Operators

Comments

- **Significant time and efforts are necessary necessary to re-establish normal conditions**

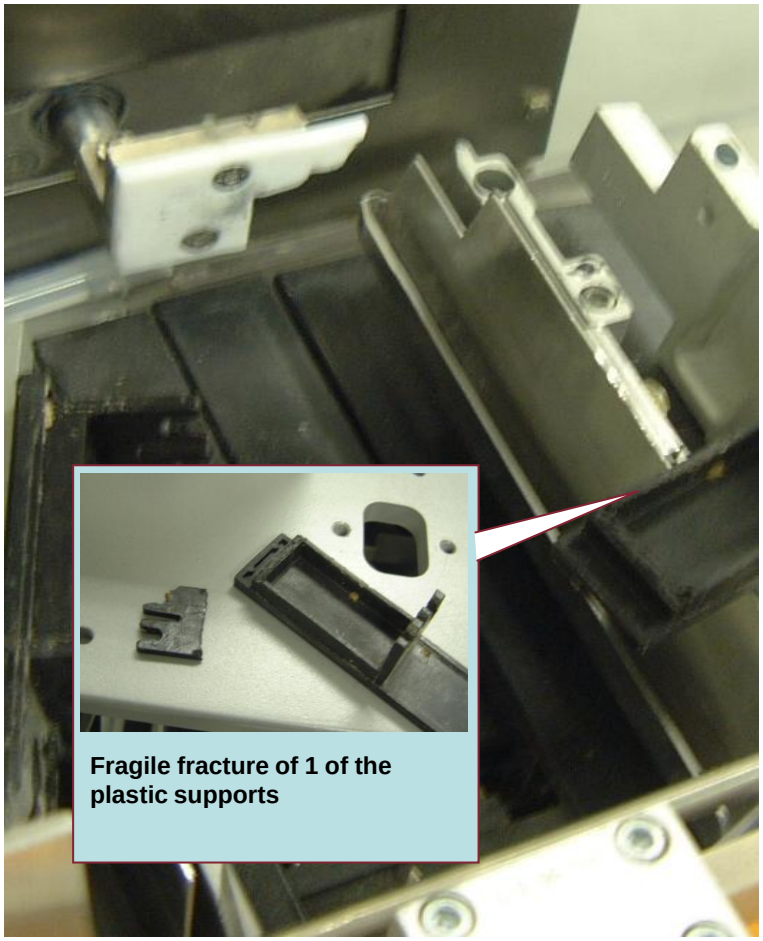
Scrap can be generated, depending on seriousness of event

Comments

- **Less serious events generate scrap of packaging materials only**

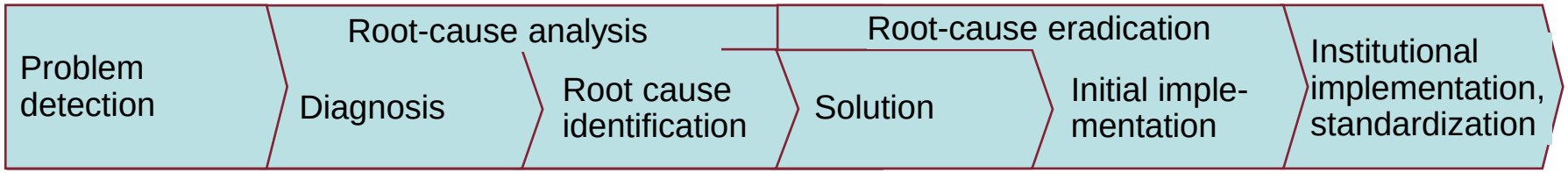
Problem detection - Mechanical breakdown

Mechanical breakdown event, at the conveyor of Line 24



Some possible first level causes	Possible root causes
• **Not correct alignment of the chain**	• **Frequency of preventive checks has to be increased?** • **Implantation systems need to be improved?**
• **Not correct interaction between conveyor, syringe/spoon**	• **Positioning system needs to be reviewed?** • **Better adjustments?**
• **Mechanical wear of the coupling system**	• **Frequency of preventive substitution needs to be increased?** • **Plastic support needs to be reinforced?**

Root cause analysis



Main steps

- Precise description of problem/defect
  - Drawings
  - Photos
  - Sketches
  - ...
- Localization of the problem (substation, ...)
- Detailed description of occurrence modalities
  - Video
  - Description of dynamic
  - ....
- Root cause hypotheses

- Systematic investigation to cover all possible causes major and root causes (complete defect tree, fishbone diagram, ...)
- Documentation of cause hypotheses and interim solutions

- Reproducible evidence (through simulation of defect/ solution)
- Confirmation of root causes

- Implementation plan for selected solution)
- Test results or model trials, costs, time needed for possible solutions

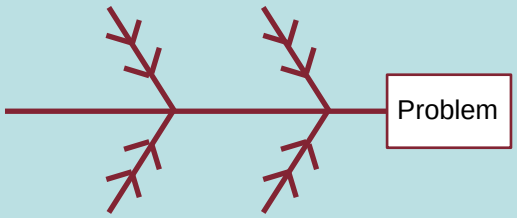
- Solution implemented for root cause
- Verification of defect eradication

- Defects, root causes, and corrective actions documented
- Standards derived, documented, and communicated

Shop floor problem solving - Root cause analysis tools

ILLUSTRATIVE

Fish-bone diagram



What is it for:
- Separate causes and effects/symptoms
- Facilitates discussion and exhaustive research of all possible first-level causes
- Assume evaluation of first-level causes

When to use:
- In the problem definition phase to narrow down its scope
- In the preliminary phase of analyzing a problem
- To compile a list of possible first-level causes

5 Whys

- Why _____
- Why _____
- Why _____
- Why _____
- Why _____

What is it for
- To deepen the analysis of a problem
- To structure the analyses needed to narrow the search for the ultimate causes
- To identify areas of further investigation to which to assign resources and activities

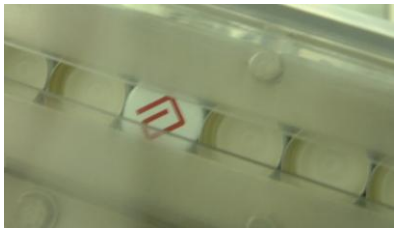
When to use it:
- After a clear identification of the problem
- When the first-level causes are clear
- To deepen the level of analysis of the problem

Root cause analysis example

Identification of root causes

Final effect: the problem

Major cause 1



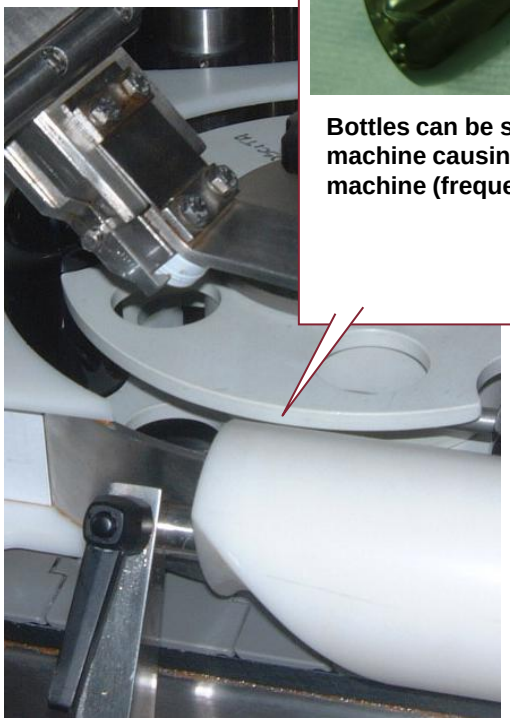
The cap is delivered in the wrong position

The root-cause of the problem can be hidden in the upstream process (arranging machine)

Other possible root causes?

Other possible major causes?

Bottles can be squeezed in the dosing machine causing stops to clean the machine (frequent small stop)



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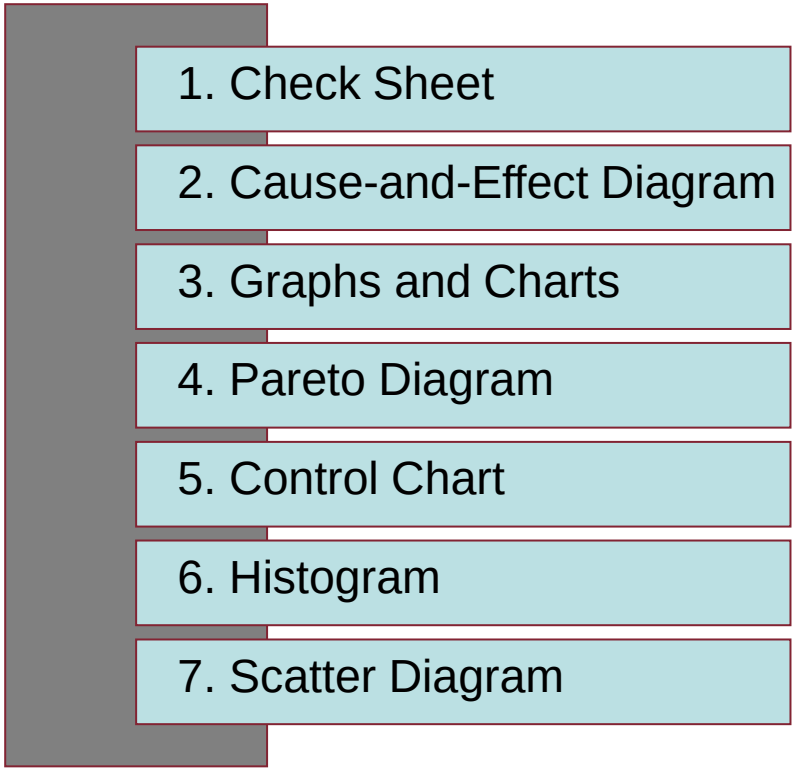
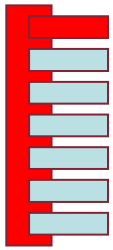
Root cause analysis - The 7 QC tools

The 7 classic QC tools are essential in gathering data and analyzing problems, they also make relevant information visible



Check sheet

The check sheet: gathering and organizing data



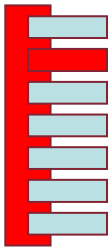
DEFECTS IN FINAL ASSEMBLY						
WEEK: March 2-6			RESP. SUPERVISOR: Glen			
DEFECT	MO	TU	WE	TH	FR	TOTAL
A	|||					3
B	|					1
C	|||		|		|	5
D	𝍸	𝍸	||	|	||	15
E	𝍸	|||	|||	𝍸	||	18
TOTAL	17	8	6	6	5	42

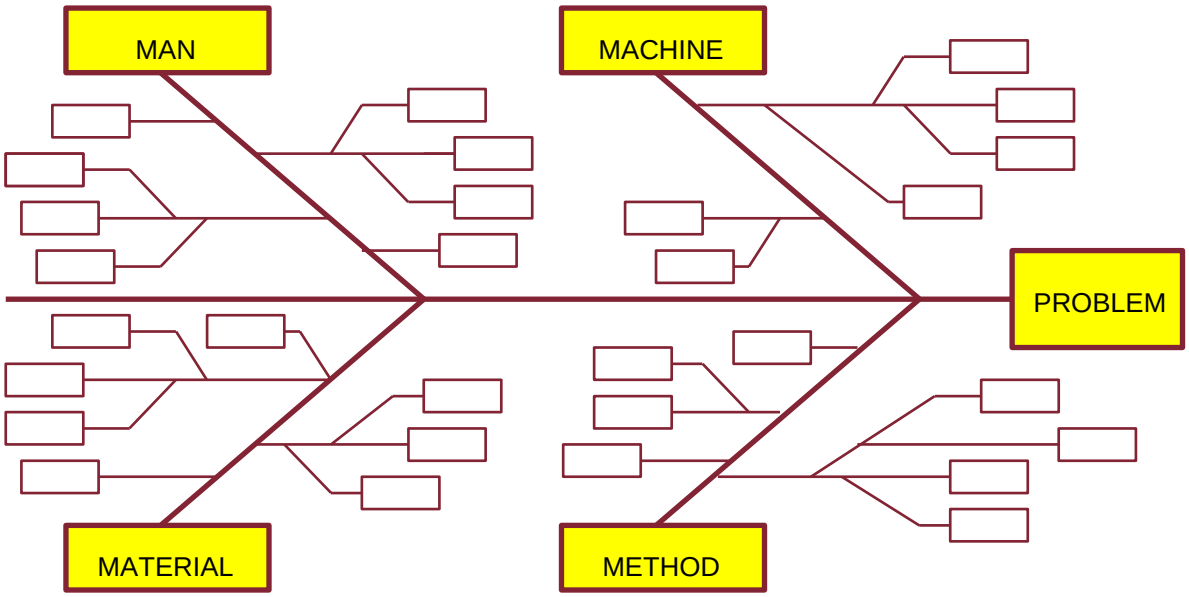
Questions answered with tool

- What fact base or data patterns will help us to better understand the problem and its cause(s)?
- How do we translate our "opinions" about the problem into "facts"?
- Are there patterns in the events surrounding the problem that shed light on the drivers or causes of the problem?

Cause-and-effect diagram

The cause-and-effect or fishbone diagram: showing possible causes of a specific problem





Questions answered with tool

How do we identify, explore, and display the possible causes of a specific problem or condition?

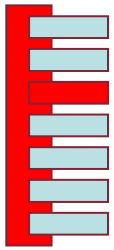
What are the root cause(s) of the problem?

Which factors are important in size?

Which factors are potentially open to change by the team?

What specific "cause" or driver of the problem do we want to tackle in our performance goal?

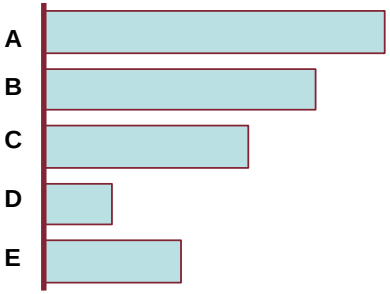
Charts and graphs



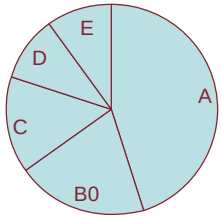
Charts and graphs: analyzing and presenting different types of data

Run Chart

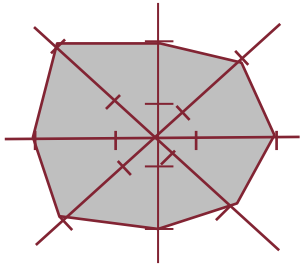
Bar Chart



Pie Chart



Radar Chart



Questions answered with these tools

What are the trends or patterns in the data over time?

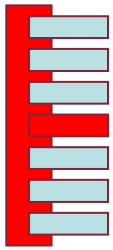
Is the average changing over time?

Do the results vary over time? Is there cyclicality (e.g., day of week or seasonal)?

Do particular times, shifts, or operating practices show more problems than others?

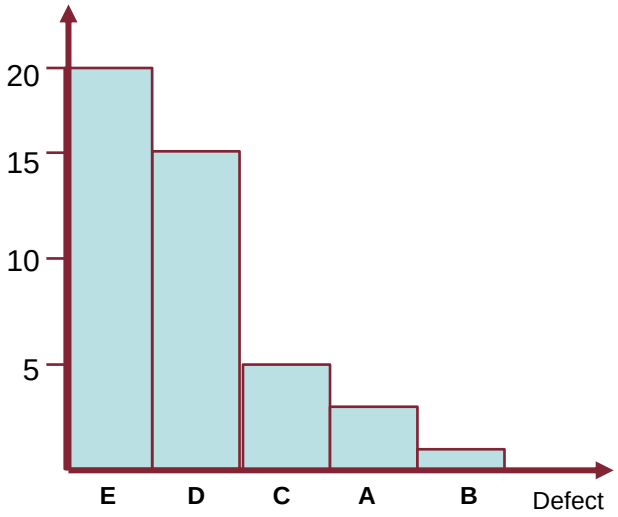
Pareto diagram

The Pareto Diagram: showing the relative importance of problems, causes, or effects



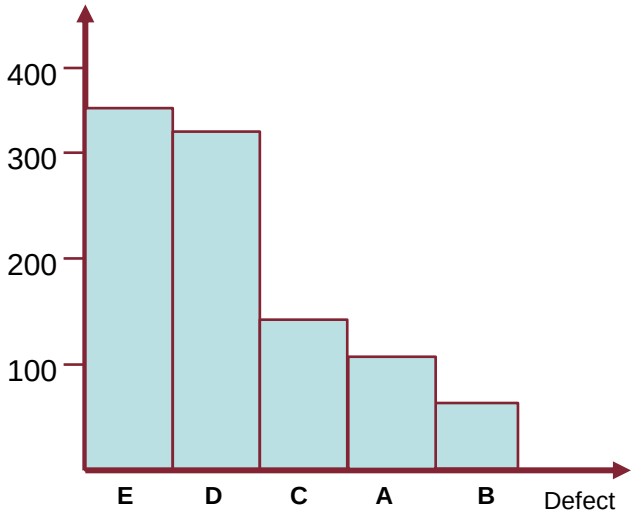
Ranking of problems (number of events)

Frequency (defects/week)



Ranking of problems (cost)

Rework cost/week, dollars



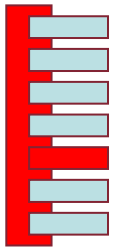
Questions answered with tool

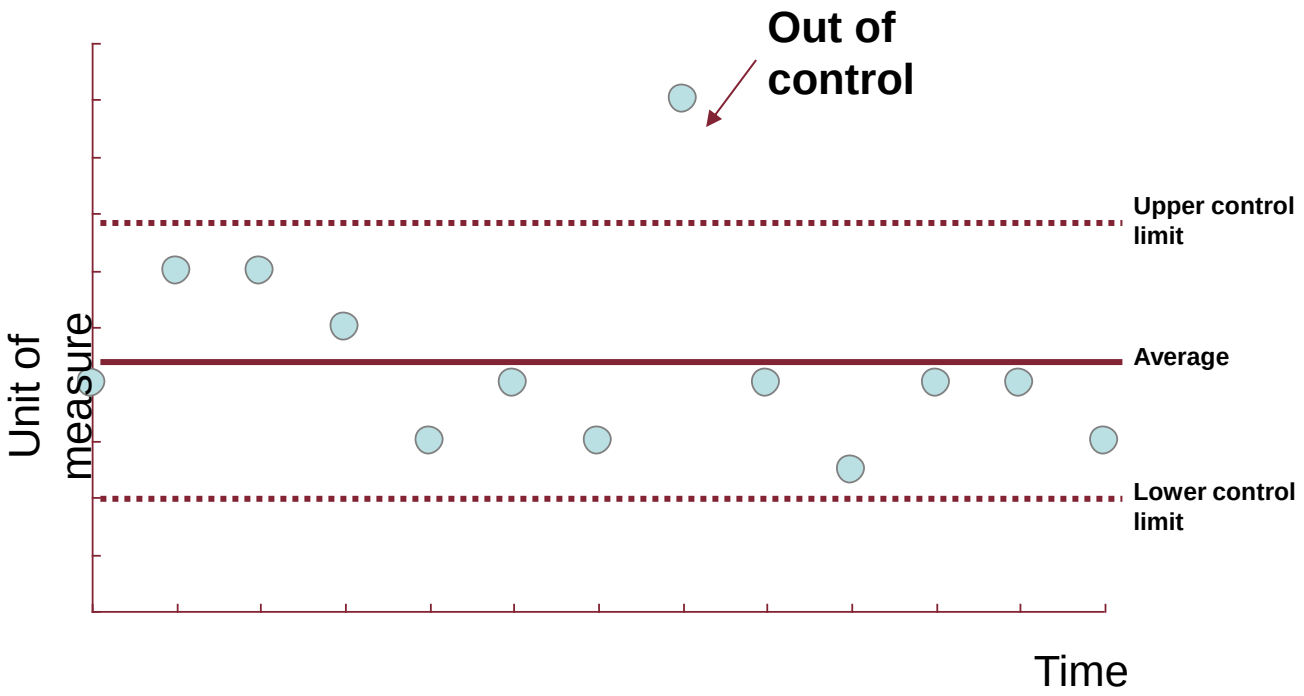
What is the relative importance of all of the problems or conditions?

What should be the starting point for problem solving? Where should we focus our attention?

Control chart

The Control Chart: understanding variability in a process (random variation vs. unique events)





Questions answered with tool

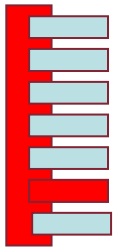
Of the variation we observe in a process parameter what part is natural variation – within the process control limits – and what part is abnormal variation due to identifiable causes?

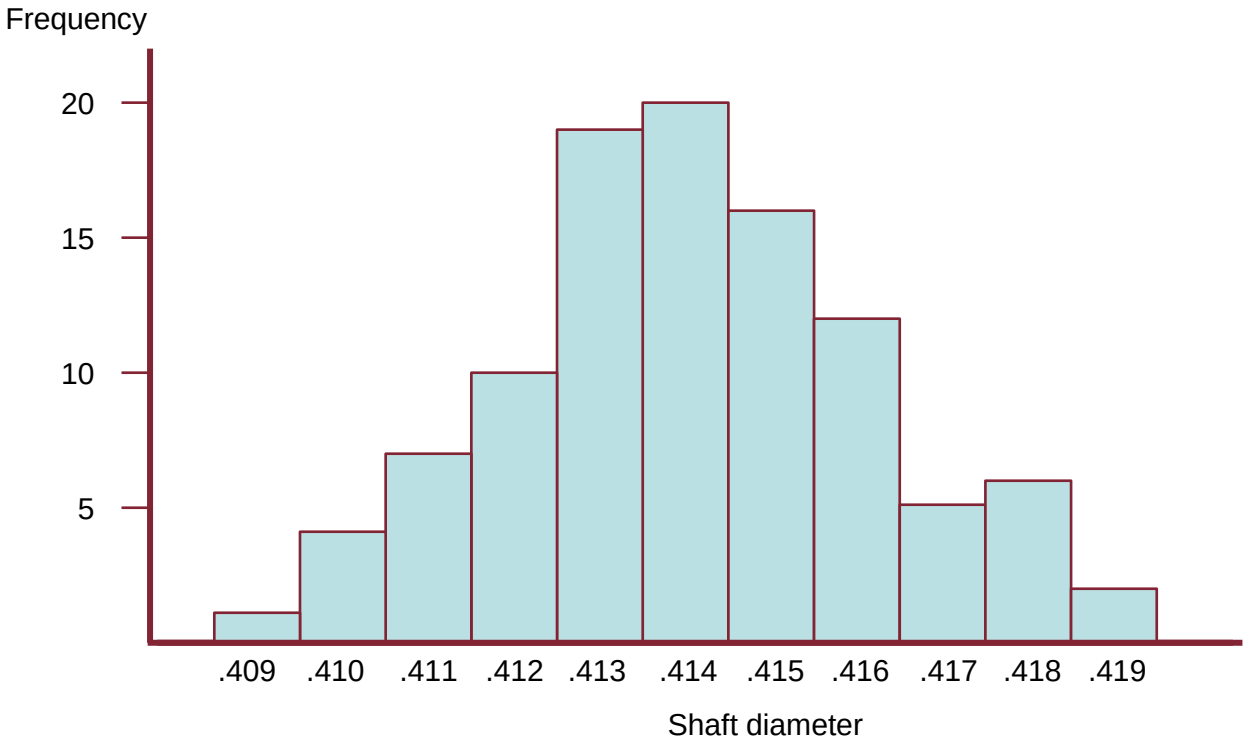
How often does the process go out of control?

Are there any discernible trends that should concern us? Can any preventive actions be taken based on these trends?

Histogram

The Histogram: showing the distribution of data





Questions answered with tool

How frequently does a certain effect occur?

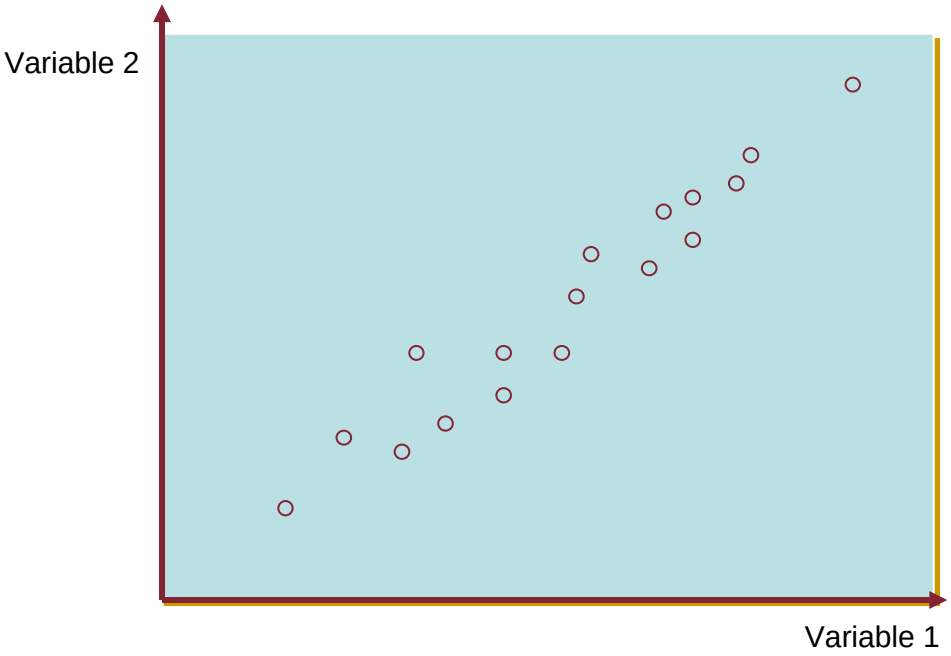
What does the frequency distribution look like – a normal curve or some other statistical form?

How frequently am I outside of specifications?

What is the nature of the deviation outside of specifications, e.g., skewed mean, long tails on distribution, uneven distribution?

Scatter diagram

The Scatter Diagram: testing a theory about a relationship between variables



Questions answered with tool

What variables are correlated?

What is the nature of the relationship between the variables?

How much of the variation in x is explained by related variation in y?

What is the cause and effect relationship between variables?

Recap, Q&A and Homework Assignment

Recap of Key Points

- Lean production focuses on eliminating waste and improving efficiency.
- Minimizes inventory and reduces production timelines by producing only what is needed.
- Emphasizes continuous improvement and customer satisfaction to enhance product quality.

Homework Assignment

- **Task:** Research a company that has successfully implemented Lean production methodologies
- **Deliverable**: Write a 1-page report describing the company's approach, the benefits achieved, and the challenges faced.