Quality

Introduction

Quality Introduction

I said that the worst thing about healthcare would be waiting, not true; worst thing are defects

Two dimensions of quality: conformance and performance

Our focus will be on conformance quality

Motivating example: the sinking ship / swiss cheese logic

Assembly Line Defects

Assembly operations for a Lap-top

9 Steps

Each of them has a 1% probability of failure

⇒What is the probability of a defect?

The Duke Transplant Tragedy

17 year old Jesica Santillan died following an organ transplant (heart+lung)

Mismatch in blood type between the donor and Jesica

Experienced surgeon, high reputation health system

About one dozen care givers did not notice the mismatch

The offering organization did not check, as they had contacted the surgeon with another recipient in mind

The surgeon did not check and assumed the organization offering the organ had checked

It was the middle of the night / enormous time pressure / aggressive time line

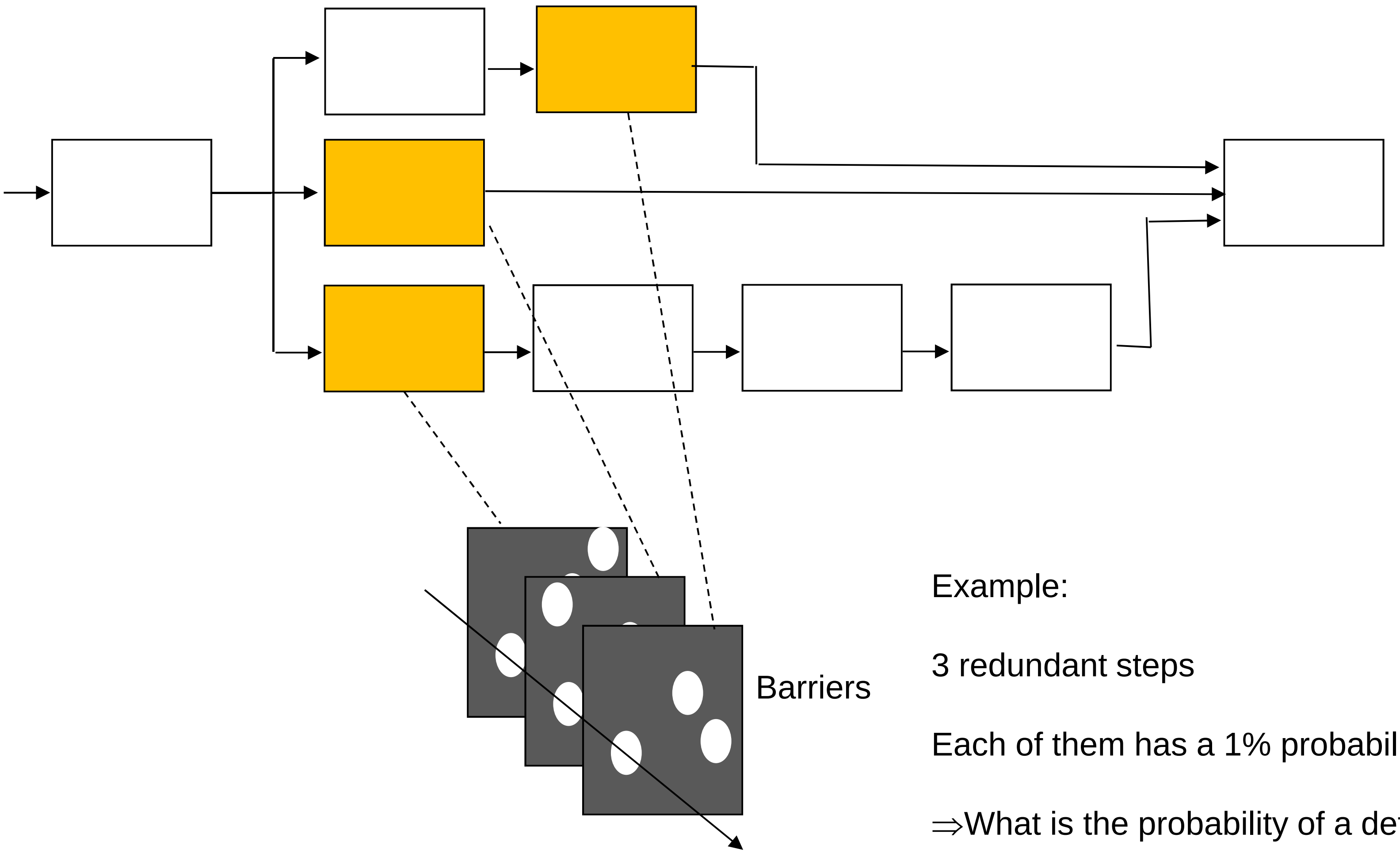
⇒ A system of redundant checks was in place

A single mistake would have been caught

But if a number of problems coincided, the outcome could be tragic

Source: http://www.cbsnews.com/2100-18560_162-544162.html

Swiss Cheese Model



Example:

3 redundant steps

Each of them has a 1% probability of failure

⇒What is the probability of a defect?

Source: James Reason

The Nature of Defects

Assembly line example: ONE thing goes wrong and the unit is defective

Swiss cheese situations: ALL things have to go wrong to lead to a fatal outcome

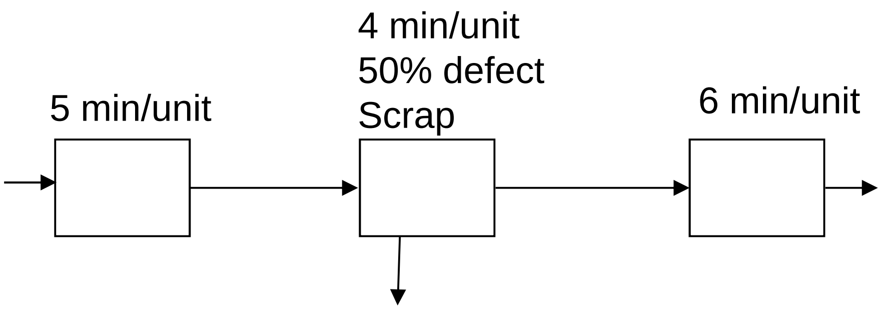
Compute overall defect probability / process yield

When improving the process, don't just go after the bad outcomes, but also after the internal process variation (near misses)

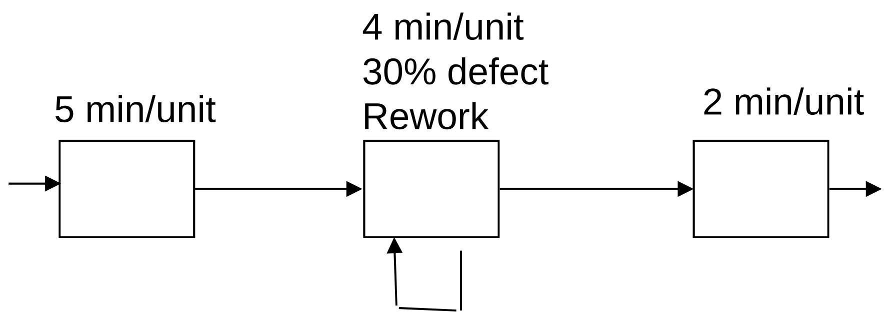
Quality

Defects / impact on flow

Impact of Defects on Flow



Impact of Defects on Flow

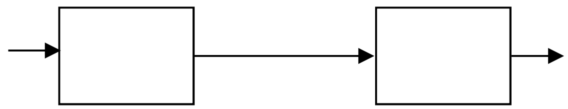


Impact of Defects on Variability: Buffer or Suffer

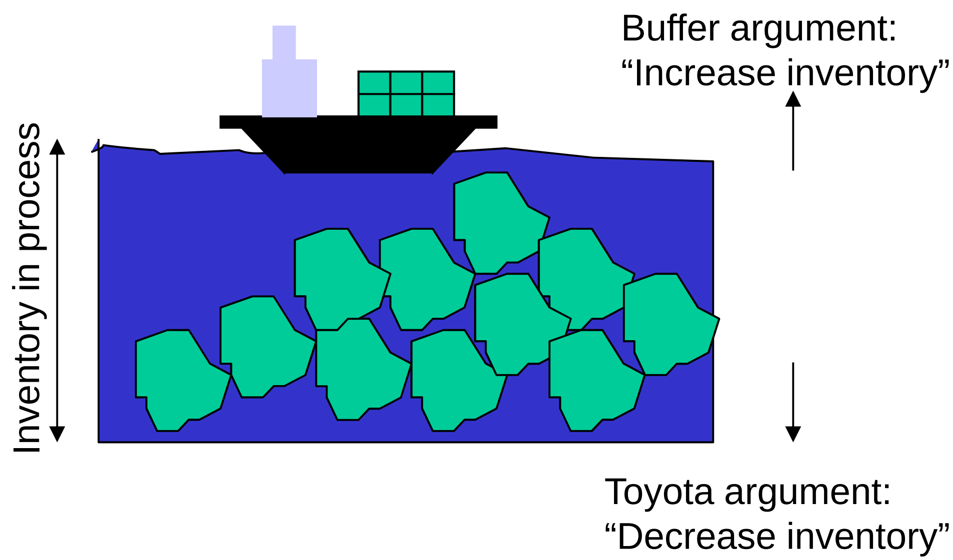
Processing time of 5 min/unit at each resource (perfect balance)

With a probability of 50%, there is a defect at either resource and it takes 5 extra min/unit at the resource to rework

=> What is the expected flow rate?



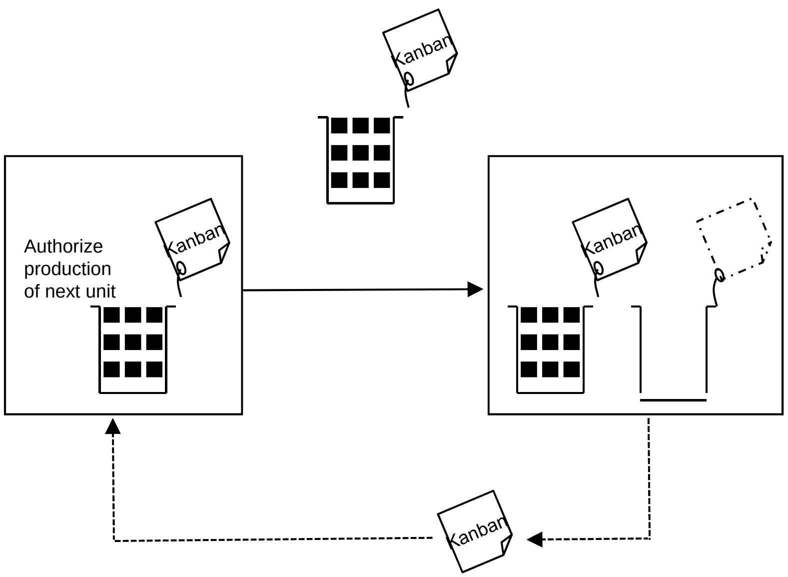
The Impact of Inventory on Quality



Inventory takes pressure off the resources (they feel buffered): demonstrated behavioral effects

Expose problems instead of hiding them

Operations of a Kanban System: Demand Pull



- Visual way to implement a pull system
- Amount of WIP is determined by number of cards

- Kanban = Sign board
- Work needs to be authorized by demand

Quality

Six sigma and process capability

Intro: two types of variability

Gurkenverordnung:
http://de.wikipedia.org/wiki/Verordnung_(EWG)_Nr._1677/88_(Gurkenverordnung)

Failure of a pharmacy

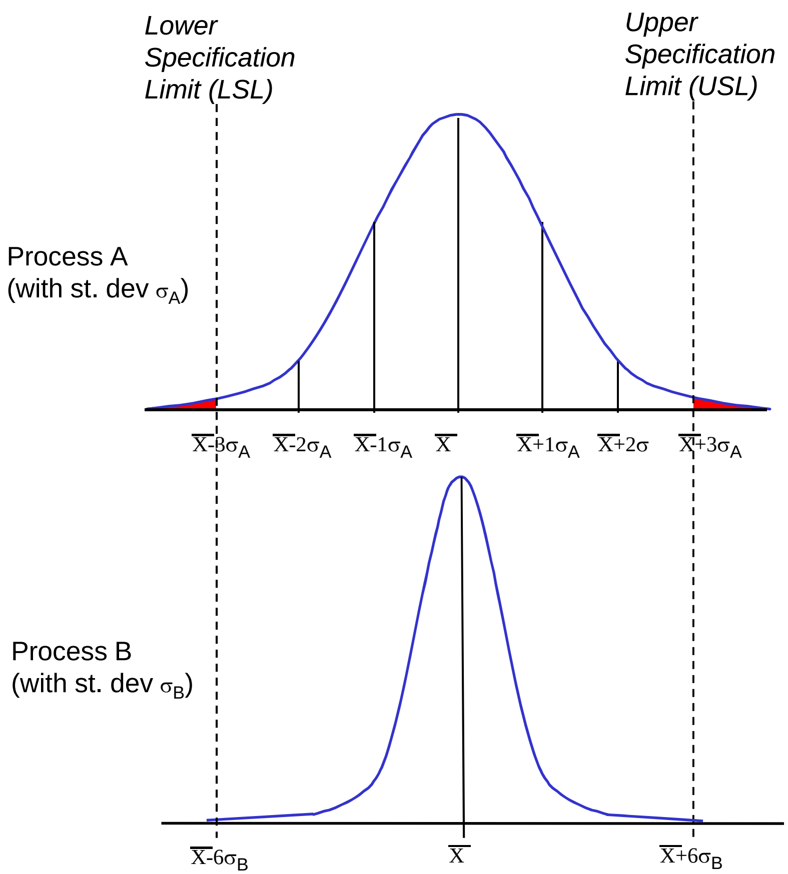
M&M Exercise

A bag of M&M’s should be between 48 and 52g

Measure the samples on your table:
- Measure x1, x2, x3, x4, x5
- Compute the mean (x-bar) and the standard deviation
- Number of defects

All data will be compiled in master spread sheet
- Yield = %tage of units according to specifications
- How many defects will we have in 1MM bags?

Measure Process Capability:
Quantifying the Common Cause Variation



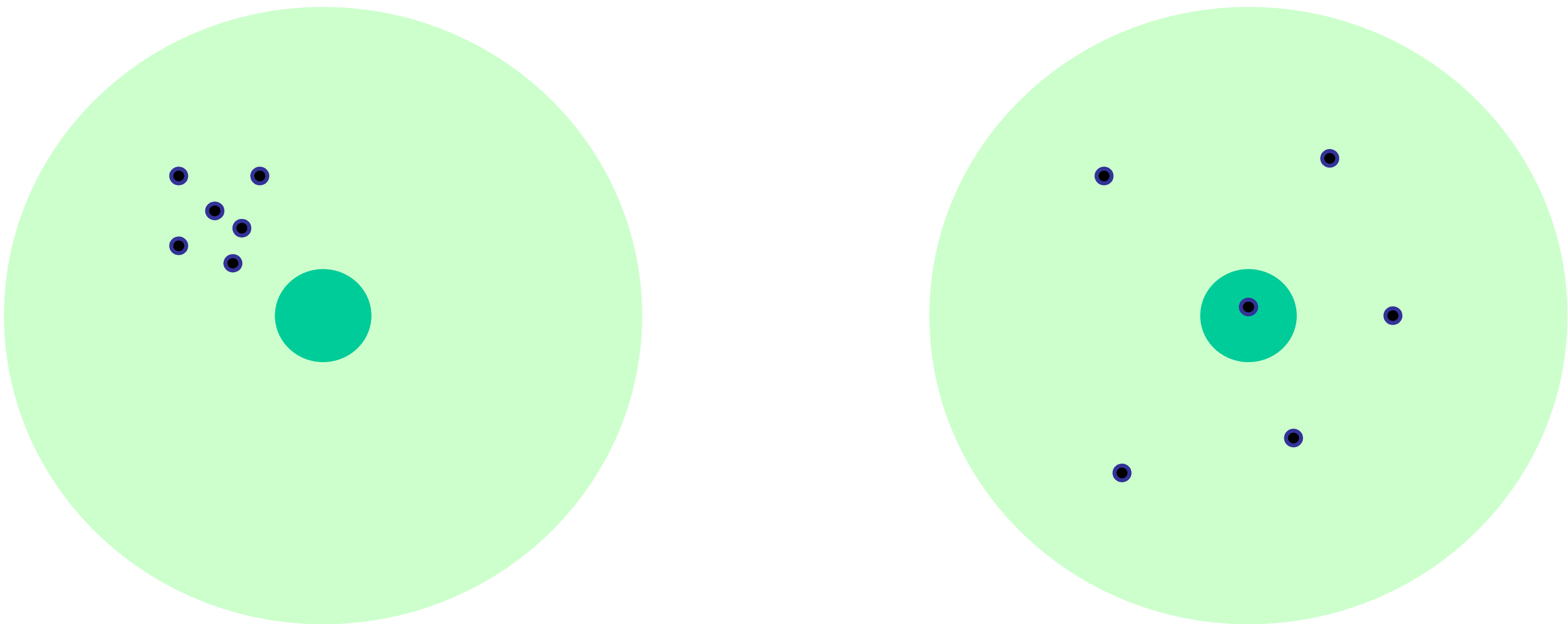
Process capability measure

$$C_p = \frac{USL - LSL}{6\hat{\sigma}}$$

xσ	C_p	P{defect}	ppm
1σ	0.33	0.317	317,000
2σ	0.67	0.0455	45,500
3σ	1.00	0.0027	2,700
4σ	1.33	0.0001	63
5σ	1.67	0.0000006	0,6
6σ	2.00	$2x10^{-9}$	0,00

- Estimate standard deviation in excel
- Look at standard deviation relative to specification limits

The Concept of Consistency: Who is the Better Target Shooter?



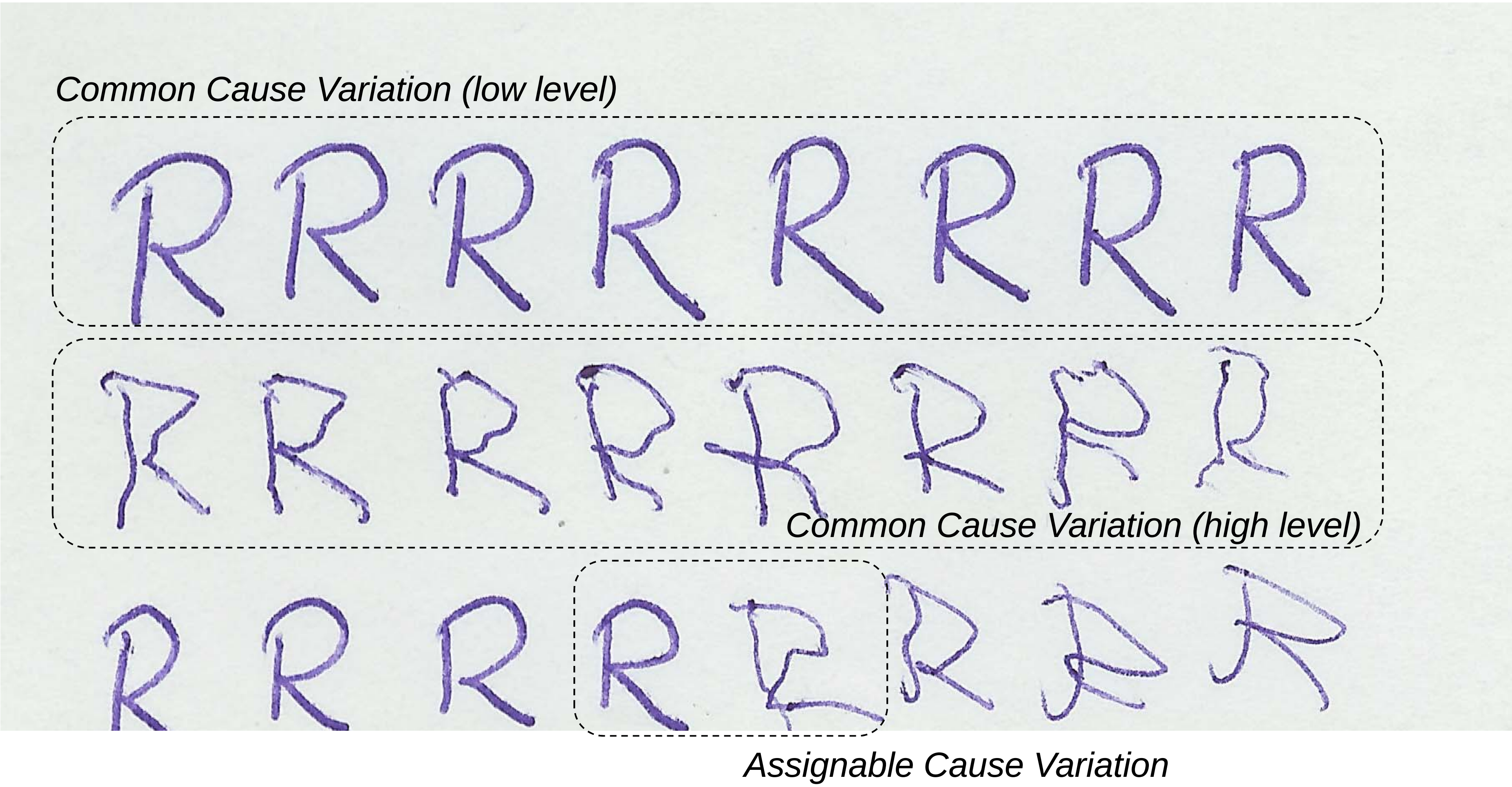
Not just the mean is important, but also the variance

Need to look at the distribution function

Quality

Two types of variation

Two Types of Variation



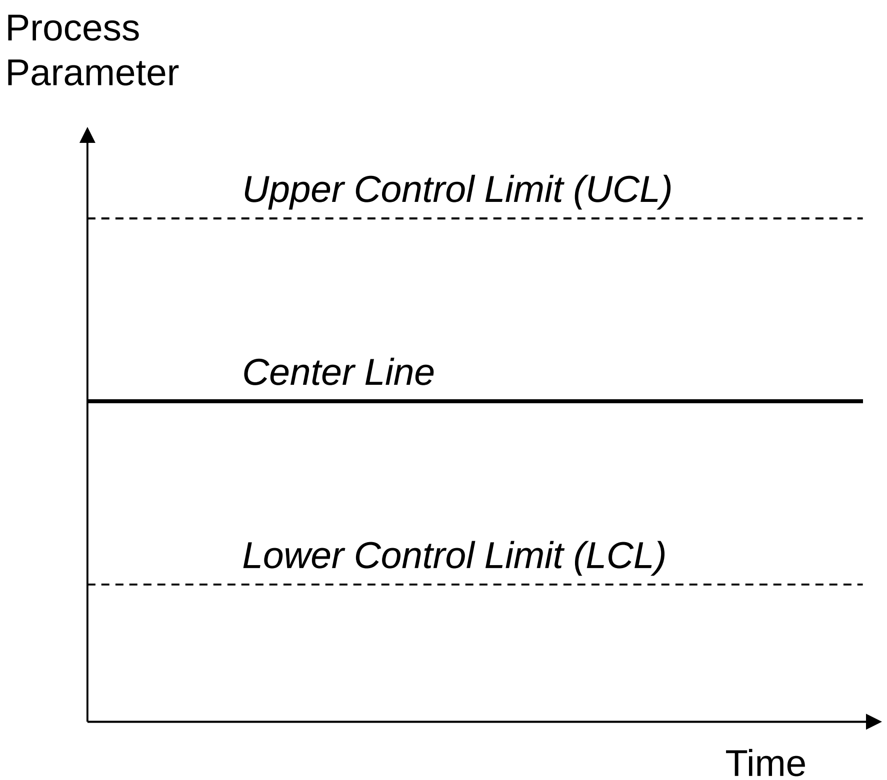
- Need to measure and reduce common cause variation
- Identify assignable cause variation as soon as possible
- What is common cause variation for one person might be assignable cause to the other

M&M Exercise

Analysis of new sample in production environment

=> Show this in Excel

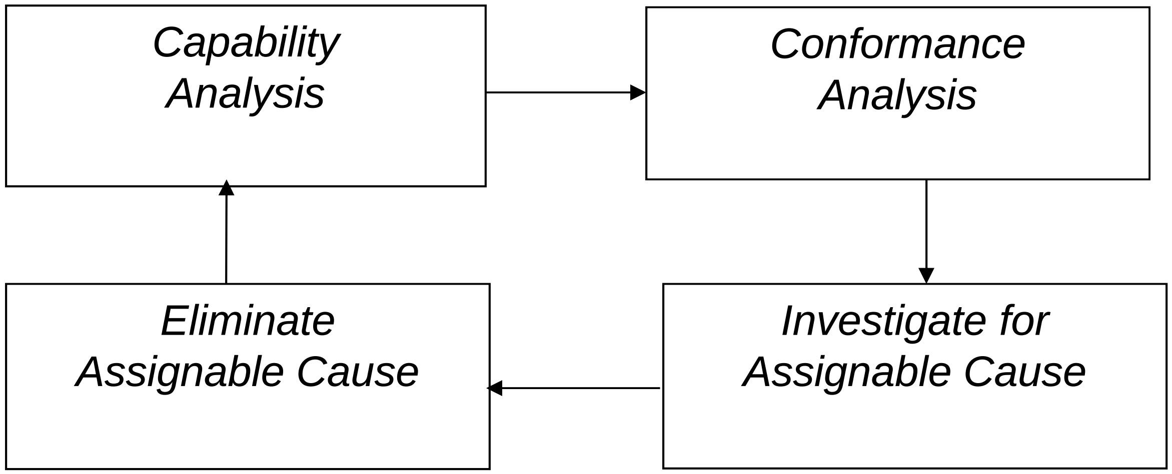
Detect Abnormal Variation in the Process: Identifying Assignable Causes



- Track process parameter over time
  - average weight of 5 bags
  - control limits
  - different from specification limits

- Distinguish between
  - common cause variation (within control limits)
  - assignable cause variation (outside control limits)

Statistical Process Control



Capability analysis
- What is the currently "inherent" capability of my process when it is "in control"?

Conformance analysis
- SPC charts identify when control has likely been lost and assignable cause variation has occurred

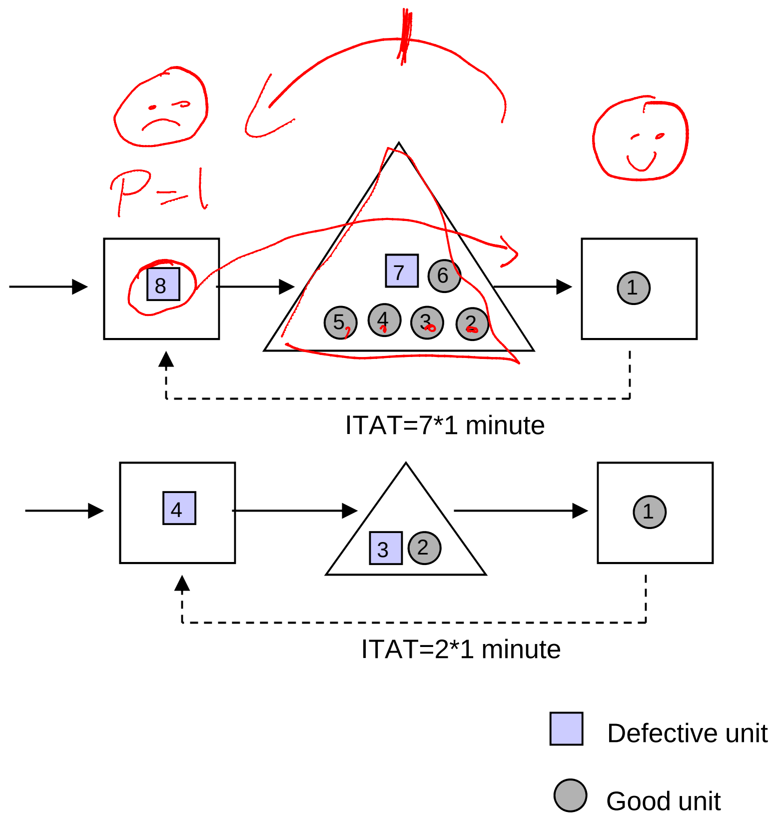
Investigate for assignable cause
- Find “Root Cause(s)” of Potential Loss of Statistical Control

Eliminate or replicate assignable cause
- Need Corrective Action To Move Forward

Quality

Detect / Stop / Alert

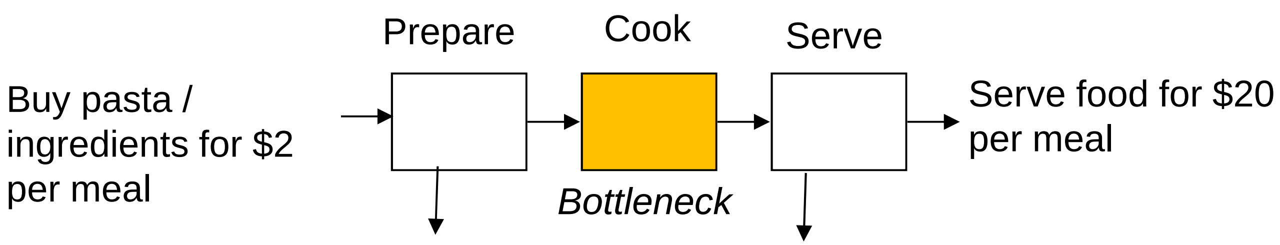
Information Turnaround Time



Assume a 1 minute processing time

Inventory leads to a longer ITAT (Information turnaround time) => slow feed-back and no learning

Cost of a Defect: Catching Defects Before the Bottleneck



What is the cost of a defect?

Defect detected before bottleneck

Defect detected after bottleneck

Detecting Abnormal Variation in the Process at Toyota: Detect – Stop - Alert

Jidoka

If equipment malfunctions / gets out of control, it shuts itself down automatically to prevent further damage

Requires the following steps:

- Detect
- Alert
- Stop

Andon Board / Cord

A way to implement Jidoka in an assembly line

Make defects visibly stand out

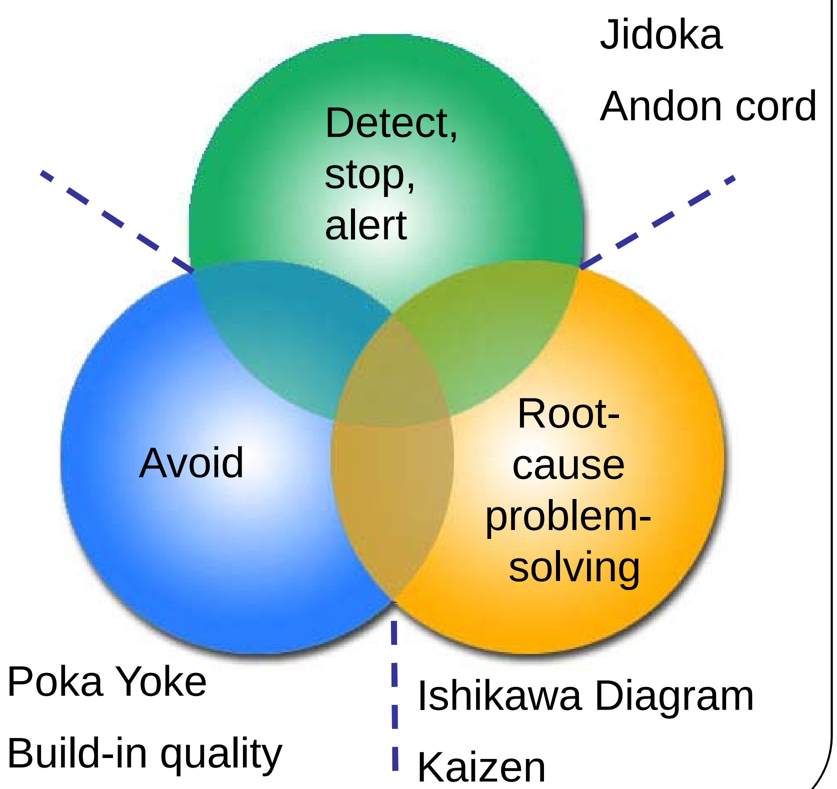
Once worker observes a defect, he shuts down the line by pulling the andon / cord

The station number appears on the andon board

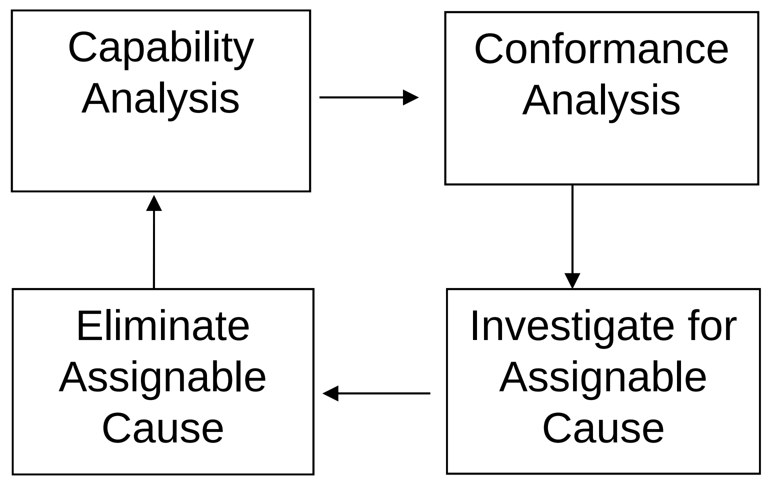
Source: www.riboparts.com, www.NYtimes.com

Two (similar) Frameworks for Managing Quality

Toyota Quality System



Six Sigma System



Some commonalities:

Avoid defects by keeping variation out of the process

If there is variation, create an alarm and trigger process improvement actions

The process is never perfect – you keep on repeating these cycles

Quality

Problem solve / improve

Root Cause Problem Solving

Ishikawa Diagram
A brainstorming technique of what might have contributed to a problem

Shaped like a fish-bone

Easy to use

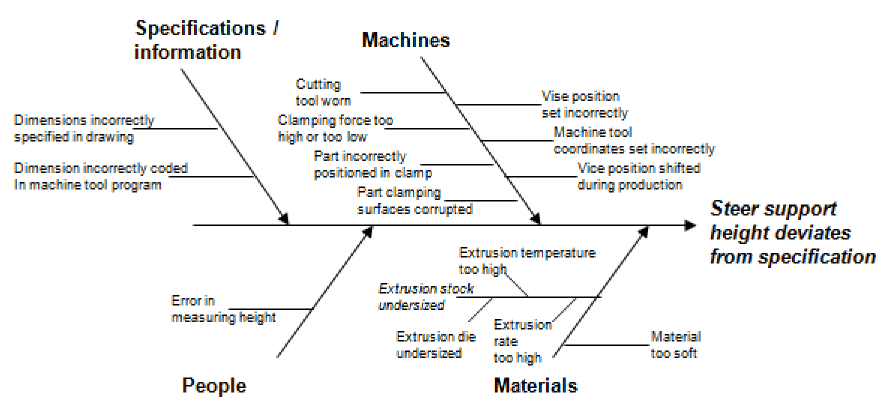
Pareto Chart
Maps out the assignable causes of a problem in the categories of the Ishikawa diagram

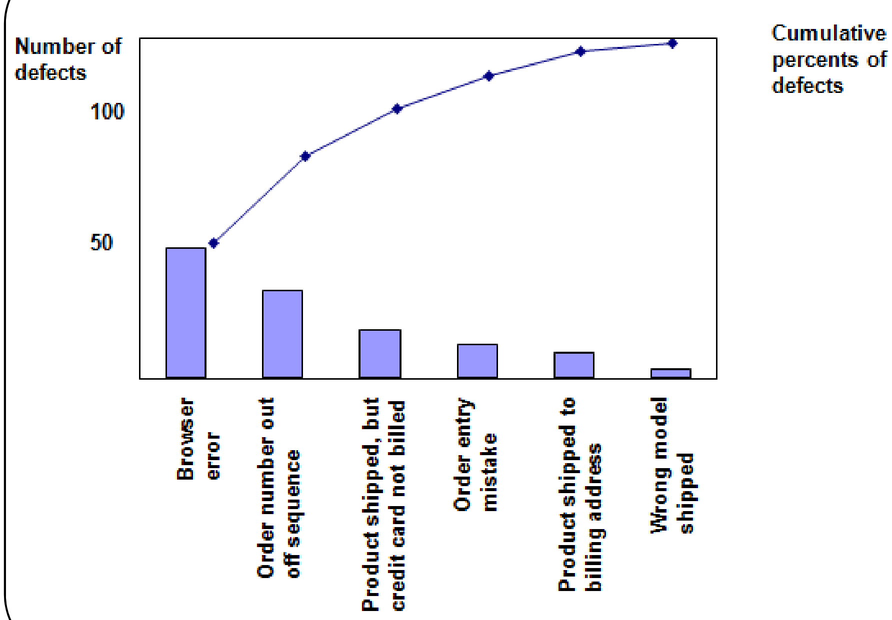
Order root causes in decreasing order of frequency of occurrence

80-20 logic

The Power of Iterative Problem-solving

Root Cause Problem Solving





Ishikawa Diagram
A brainstorming technique of what might have contributed to a problem

Shaped like a fish-bone

Easy to use

Pareto Chart
Maps out the assignable causes of a problem in the categories of the Ishikawa diagram

Order root causes in decreasing order of frequency of occurrence

80-20 logic

Conclusion

Lean Operations

The Ford Production System

Influenced by Taylor; optimization of work

The moving line / big machinery => focus on utilization

Huge batches / long production runs; low variety

Produced millions of cars even before WW2

Model built around economies of scale
=> Vehicles became affordable to the middle class

The Toyota Production System

Toyota started as a maker of automated looms

Started vehicle production just before WW2

No domestic market, especially following WW2

Tried to replicate the Ford model (produced about 10k vehicles)

No success due to the lack of scale

Around 1950, TPS was born and refined over the next 30 years
$\Rightarrow$ Systematic elimination of waste
$\Rightarrow$ Operating system built around serving demand

Introduction

Taylorism: Standardized parts and work patterns (time studies)

Moving line ensuring working at same pace

Process driven by huge, rapid machinery with inflexible batch production

1903 1st car

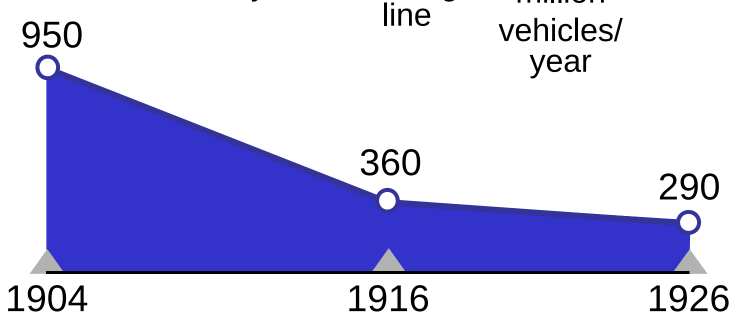
1908 1st Model T

1911 F.W. Taylor

1913 1st moving line

1923 2.1 million vehicles/ year

Cost USD/ unit



Mass production driven by economies of scale impossible

– Low production volume (1950): GM 3,656,000 – Toyota 11,000
– Low productivity (Japan 1/9 of US)
– Lack of resources

1933 Founded

1946 Major strike

1950 Start of TPS

1960s Supplier develop-ment

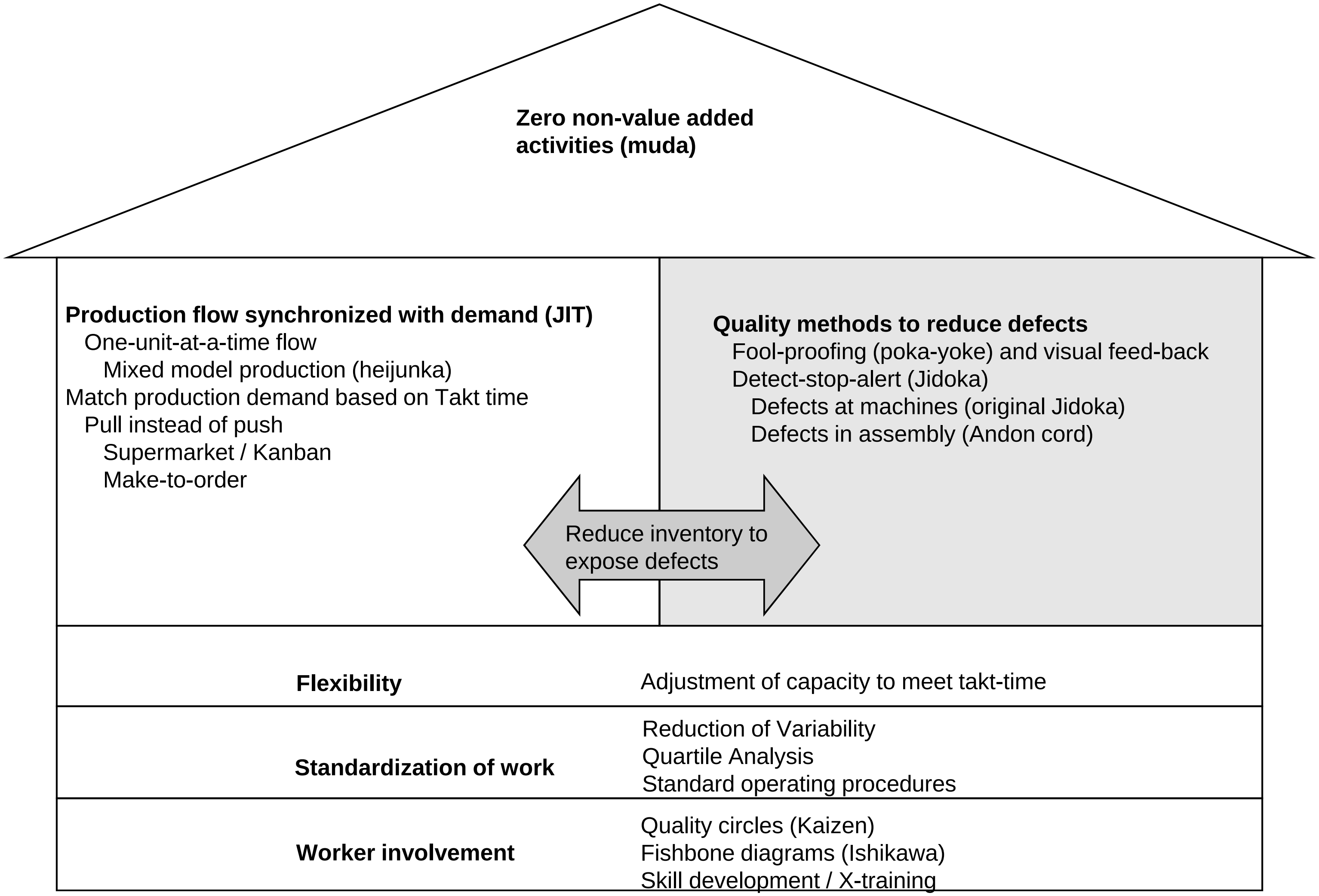
1980s Trans-plants

Key idea of TPS: systematic elimination of non-value-adding activities

Key idea of Ford: cost reduction through cheap labor and economies of scale

Source: McKinsey

Toyota Production System: An Overview



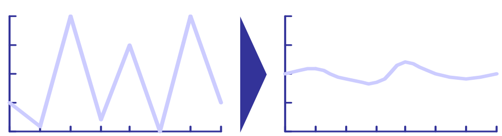
The Three Enemies of Operations

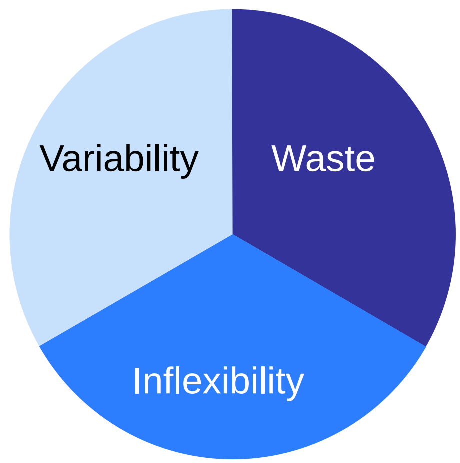
Is associated with longer wait times and / or customer loss

Requires process to hold excess capacity (idle time)

Buffer or suffer

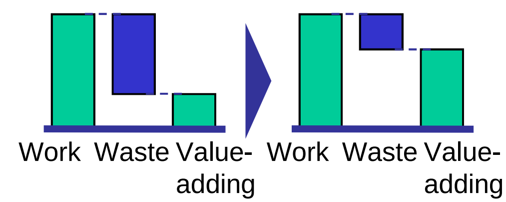
Often times: quality issues





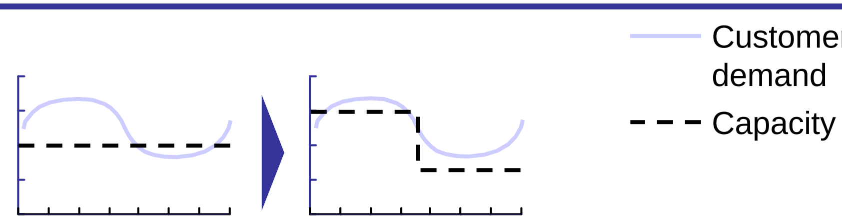
Use of resources beyond what is needed to meet customer requirements

- 7 different types of waste
- OEE framework
- Lean: do more with less



Additional costs incurred because of supply demand mismatches

- Waiting customers or
- Waiting (idle capacity)



Quality

Review Questions

Pharmacy Medication Error

A pharmacy in a Philadelphia suburb wants to investigate the likelihood of making a medication error. There are two ways in which a patient can end up with the wrong medication:

- In about 2% of the cases, the doctor fills out the prescription incorrectly. Nobody in the pharmacy catches these errors
- In about 1% of the cases, the pharmacist makes a mistake in picking the medication according to the prescription. The pharmacy has an internal quality inspection process that catches about 97% of the errors made by the pharmacist.

Another source of quality control is the patients. The pharmacy estimates that about half of the errors made by the physician are recognized by the patient. However, the patient is only able to recognize 10% of the mistakes done at the pharmacy.

What is the likelihood that the patient is presented with a wrong medication?

What is the likelihood that the patient leaves the pharmacy with the wrong medication?

Four Step Process with Rework and Scrap

Consider the following four step assembly operation with quality problems. All resources are staffed with one operator.

- The first resource has a processing time of 4 minutes per unit
- The second resource has a processing time of 3 minutes per unit. This process suffers from a high yield loss and 50% of all products have to be scrapped after this step.
- The third resource also suffers from quality problems. However, instead of scrapping the product, the third resource reworks it. The processing time at the third resource is 5 minutes per unit. In the 30% of the products in which the product needs to be reworked, this extends to a total (initial processing time plus rework) processing time of 10 minutes per unit. Rework always leads to a non-defective unit.
- No quality problems exist at the first and final resource. The processing time is 2 minutes per unit.

For every unit of demand, how many units have to flow through the third step in the process?

Where in the process is the bottleneck?

What is the process capacity?

Chicken Eggs
A farmer focusing on the production of eco-friendly chicken eggs collects the following data about his output. In a sample of 50 eggs, the farmer finds the average egg to weigh 47 grams. The standard deviation of the egg weight is 2 grams and the distribution of weights resembles a normal distribution reasonably closely.

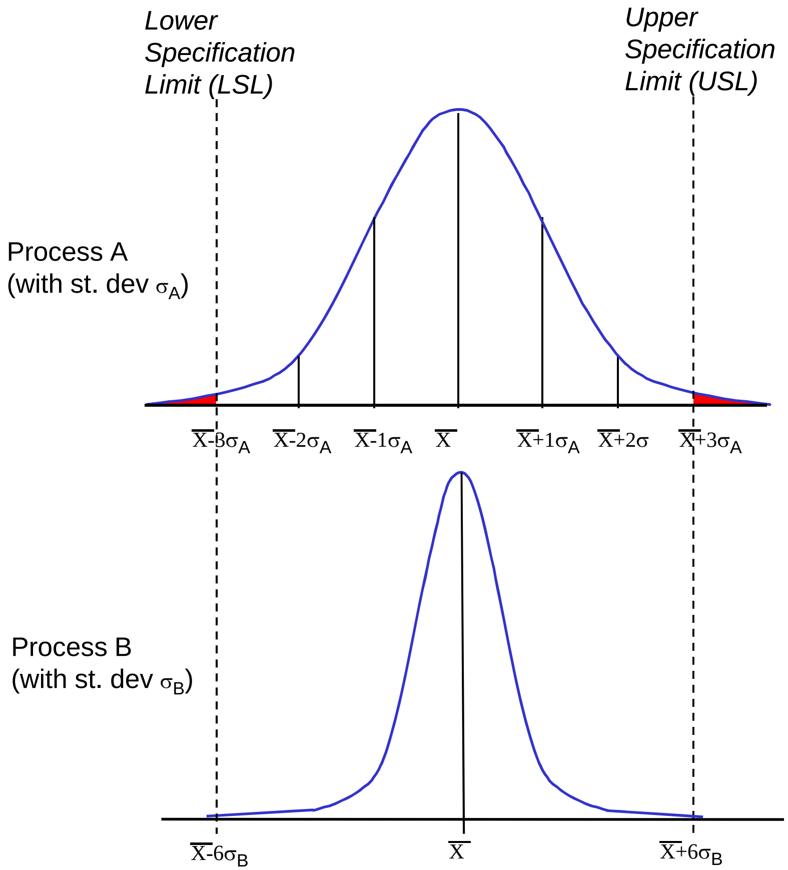
The farmer can sell the eggs to a local distributor. However, they have to be in the interval between 44 grams and 50 grams (i.e., the lower specification limit is 44 grams and the upper specification limit is 50 grams).

What is the capability score of the eco-friendly chicken egg operation?

What percentage of the produced eggs fall within the specification limits provided by the local distributor?

By how much would the farmer have to reduce the standard deviation of the operation if his goal were to obtain a capability score of Cp=2/3 (i.e., get 4.5% defects)?

Measure Process Capability: Quantifying the Common Cause Variation



Process capability measure

$$C_p = \frac{USL - LSL}{6\hat{\sigma}}$$

$x\sigma$	C_p	P{defect}	ppm
1σ	0.33	0.317	317,000
2σ	0.67	0.0455	45,500
3σ	1.00	0.0027	2,700
4σ	1.33	0.0001	63
5σ	1.67	0.0000006	0,6
6σ	2.00	$2x10^{-9}$	0,00

- Estimate standard deviation in excel
- Look at standard deviation relative to specification limits

Toyota Word Matching

Please write the letter corresponding to the most appropriate example or definition from choices (a – k below) on the blank line next to each word below.

a) Examples of this include: workers having to make unnecessary movements (i.e. excessive reaching or walking to get tools or parts), working on parts that are defective and idle time.

b) A system that enables a line worker to signal that he or she needs assistance from his or her supervisor, for example in the case of a defect. Used to implement the Jidoka principle.

c) A brainstorming technique that helps structure the process of identifying underlying causes of an (usually undesirable) outcome

d) As an example of this philosophy, workers at Toyota often times make suggestions for process improvement ideas.

e) A method that controls the amount of work-in-process inventory

f) If an automotive assembly plant used this technique, the adjacent cars on an assembly line would be mixed models (e.g. Model A with sunroof, Model A without sunroof, Model B, Model B with sunroof), in proportions equal to customer demand.

g) Making production problems visible and stopping production upon detection of defects

Please only add ONE LETTER to each of the following terms:

Kanban	____
Muda	____
Heijunka	____
Andon cord	____
Kaizen	____
Ishikawa	____
Jidoka	____