Module 10. Variation, Quality, Monitoring

Part I

QUALITY:

Reality:

- One day someone will design and make a better quality part for less.
- Customers want more (better quality, faster delivery, lower cost)

*Extracted from the movie**, Arizona Dream***

https://www.youtube.com/watch?v=AktHnnA9QIM

https://www.youtube.com/watch?v=D4qnl19axAU

THIS MODULE REVIEWS:

- Statistical Process Control
    - Control Chart
    - Process Capability Index
- Six-Sigma
- Kaizen
- Lean Manufacturing
- Monitoring (an Example)

STATISTICAL PROCESS CONTROL

Quality, Variation, Tolerance

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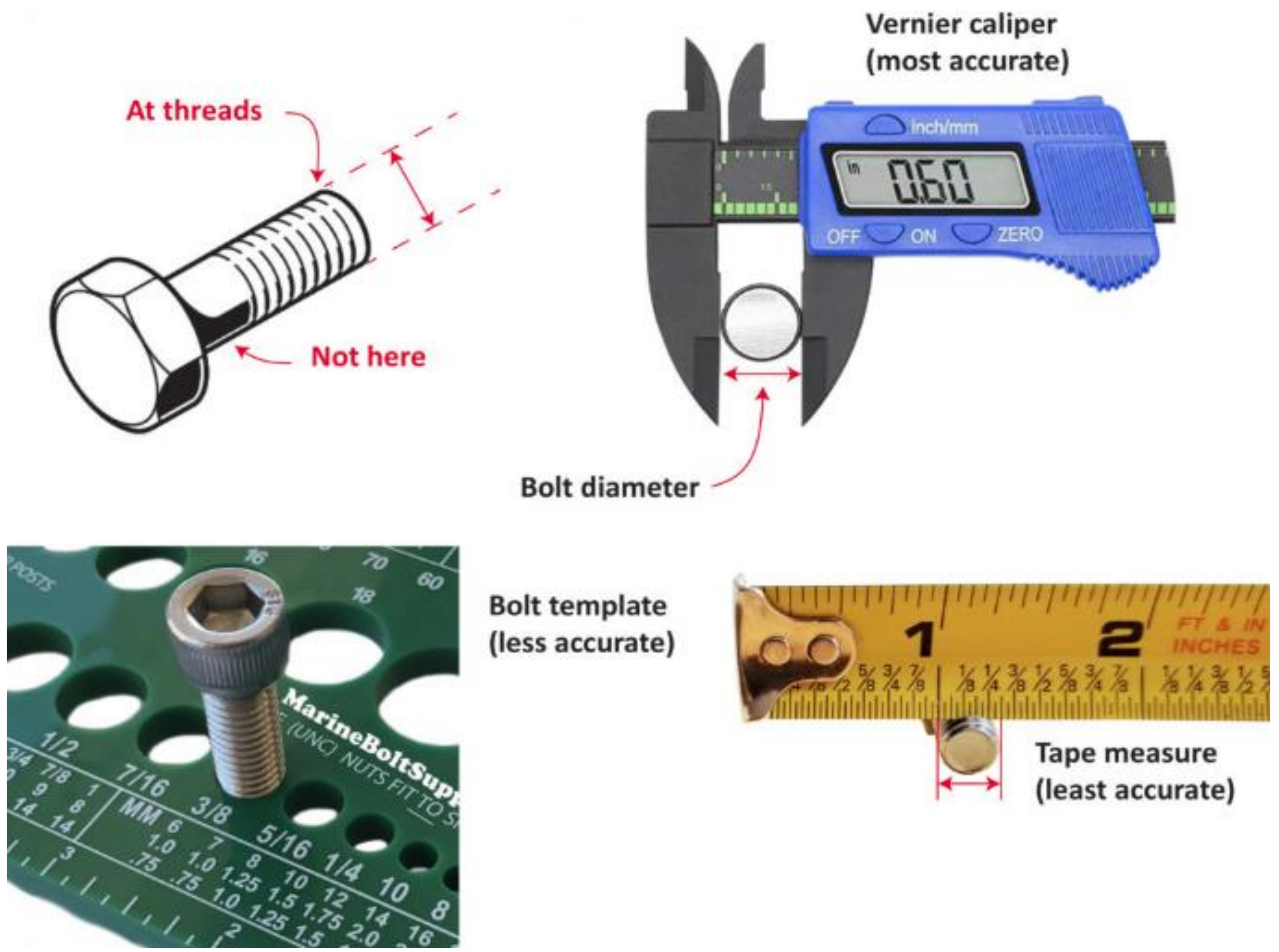

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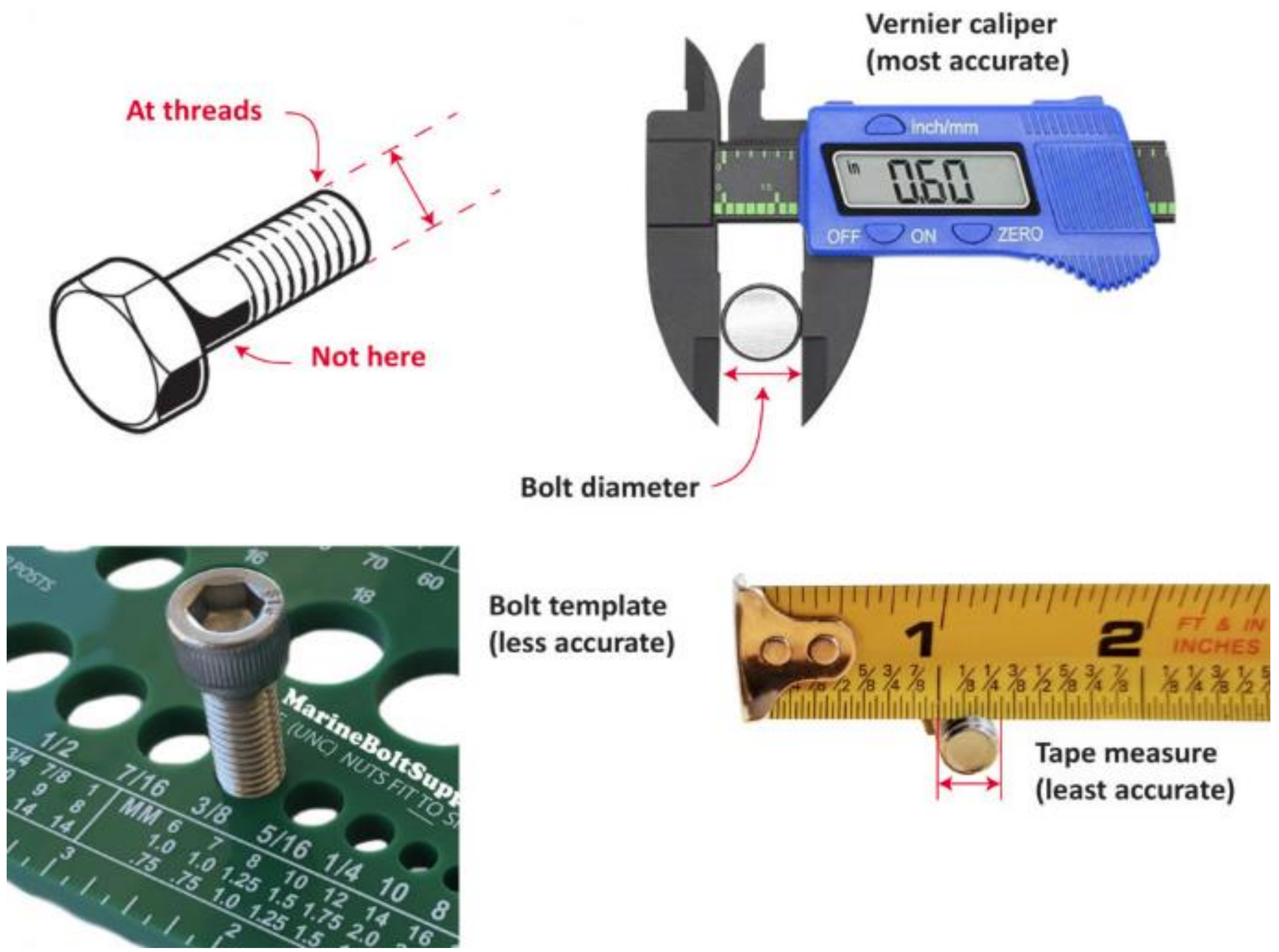
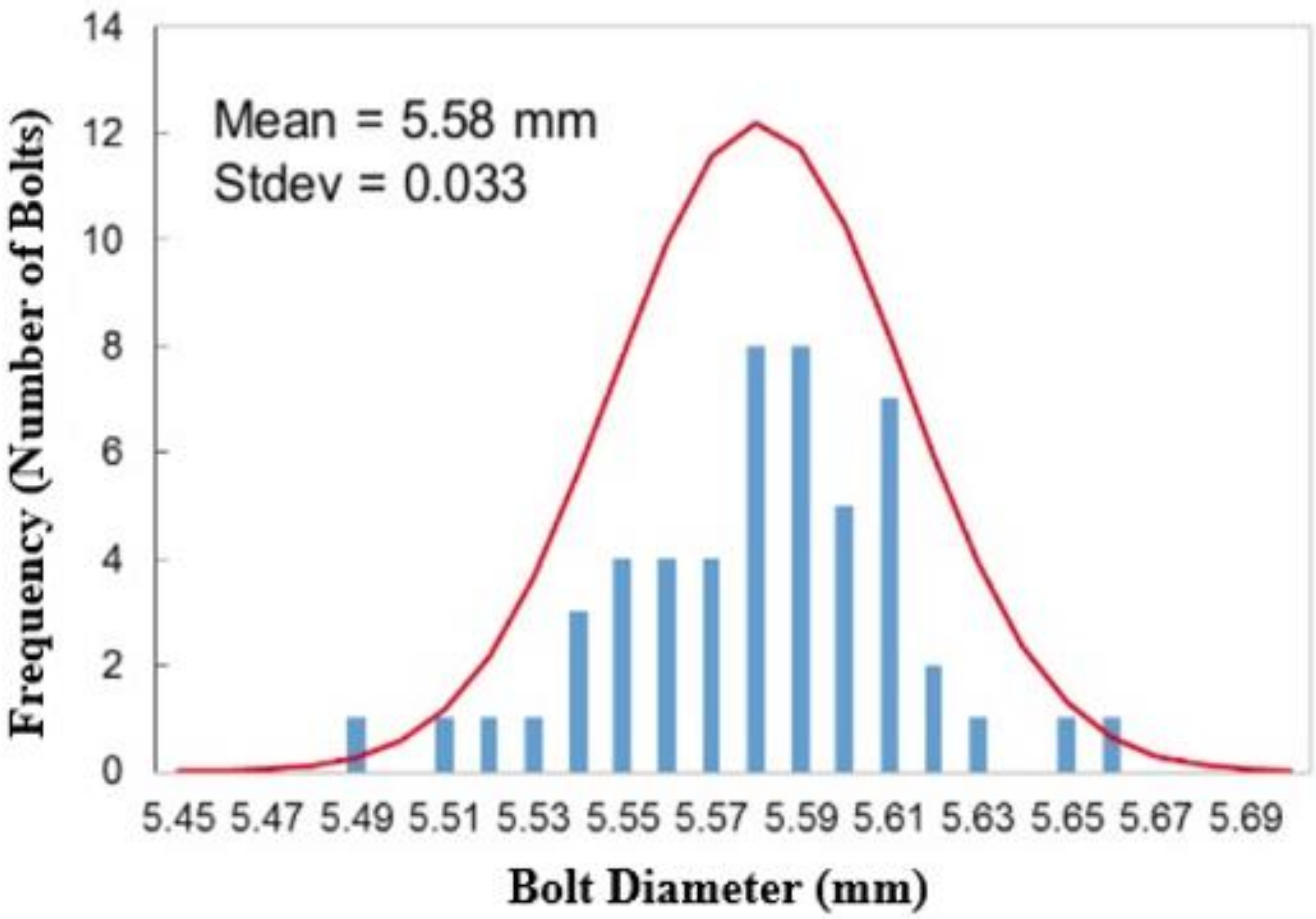




Diameter of 100 bolts were measured.

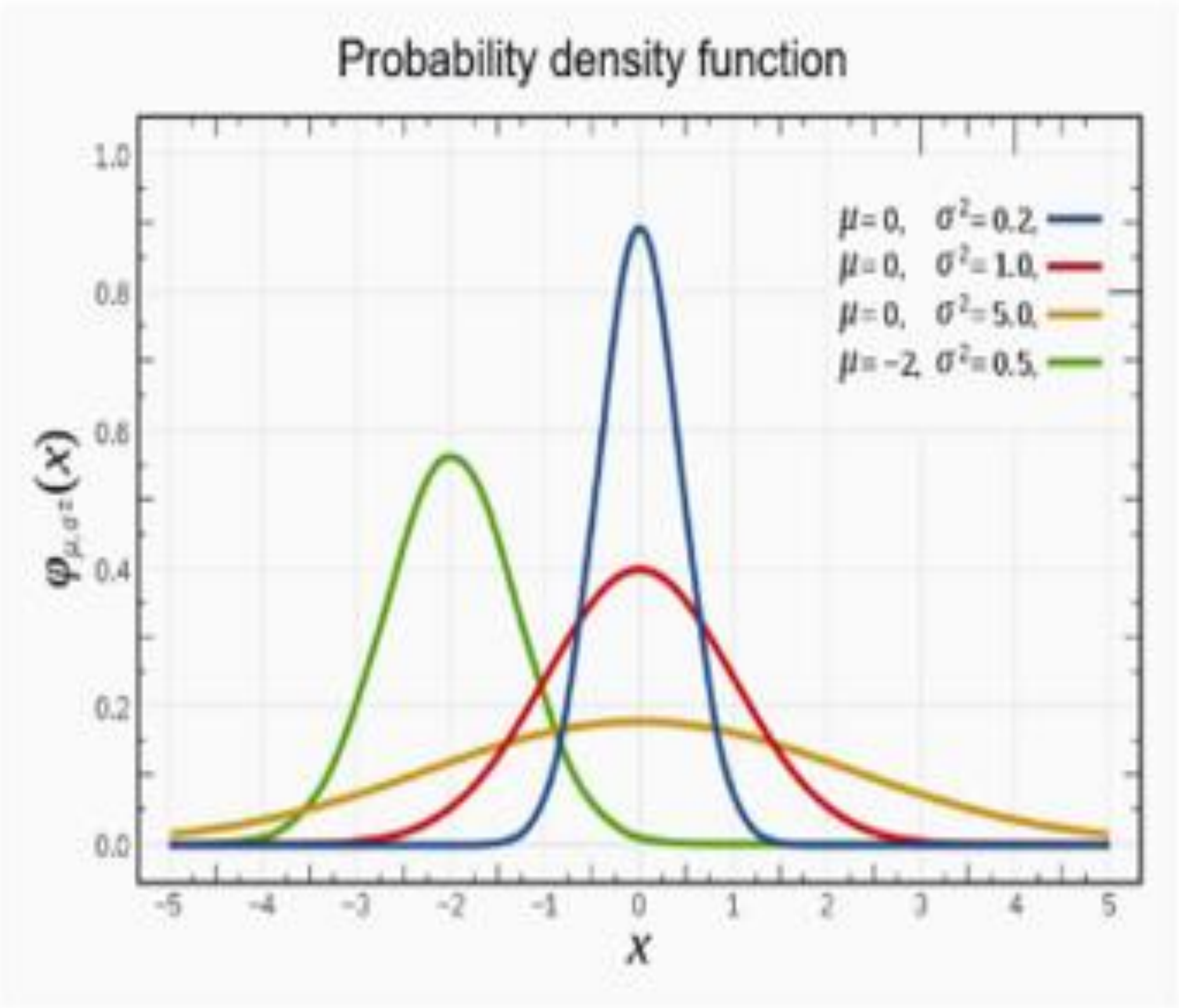
Number of Observation vs Diameter (Histogram)

NORMAL DISTRIBUTION

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}}\, e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

$$\boldsymbol{\sigma} = \sqrt{\frac{\mathbf{1}}{\boldsymbol{N}}\sum_{\boldsymbol{i}=\mathbf{1}}^{\boldsymbol{N}}(\boldsymbol{x}_{\boldsymbol{i}} - \overline{\boldsymbol{x}})}$$

μ = mean
σ = standard deviation
σ^2 = variance



Wikipedia

Assumptions for a normal distribution:

1. Small errors are more likely than large errors.
2. Positive and negative errors are equally likely.
3. The most likely of several measurements is their average.

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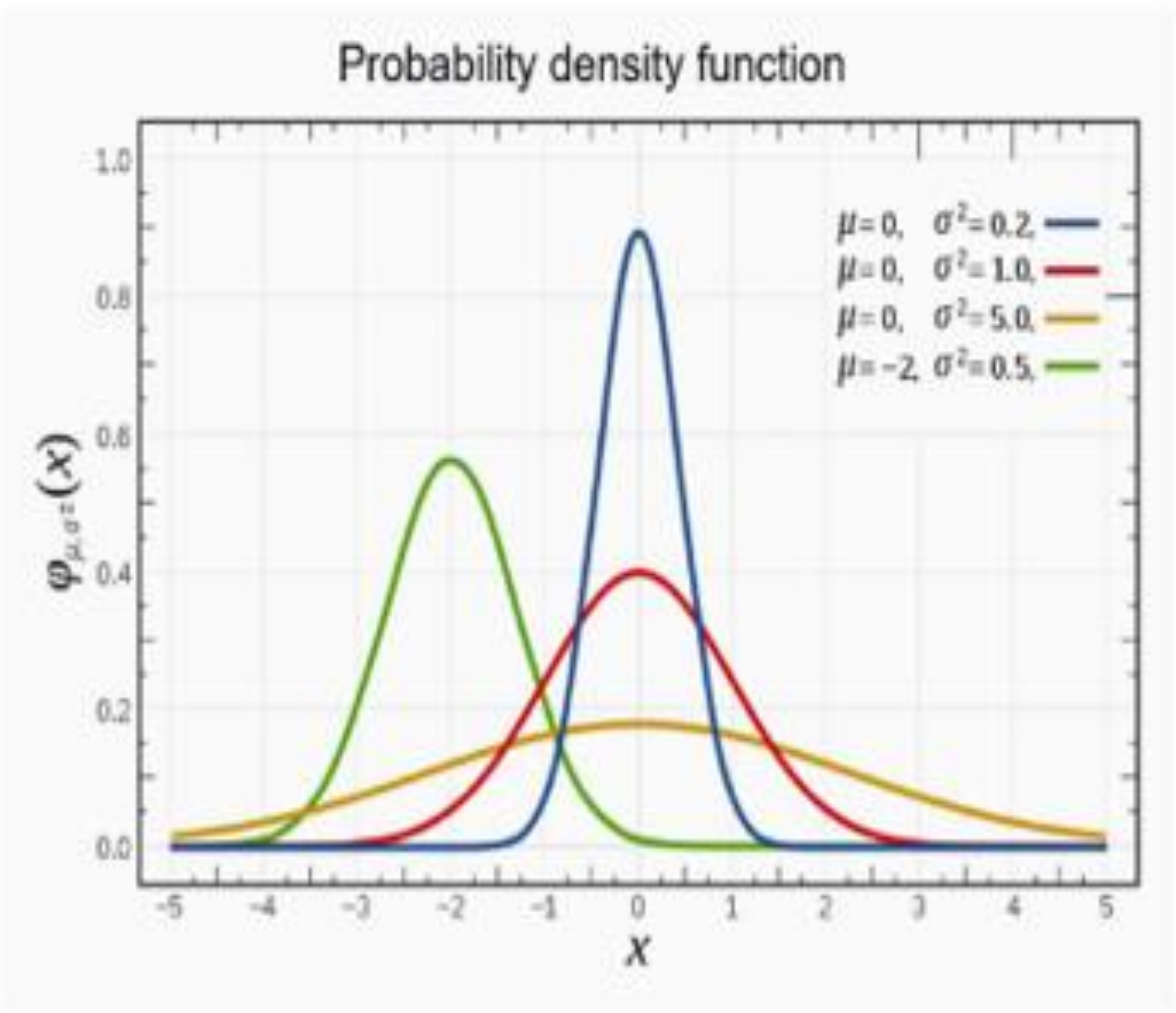
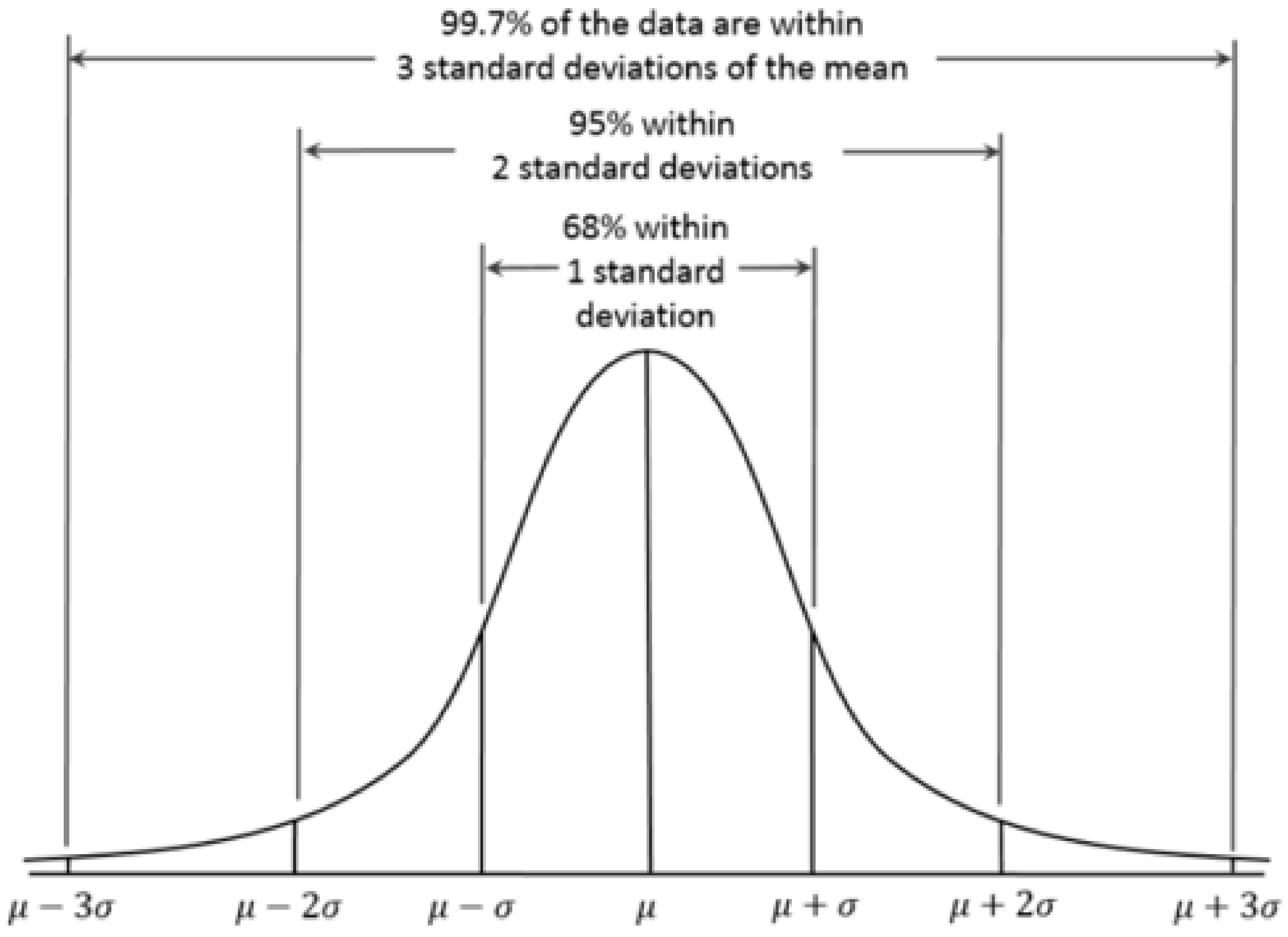


Wikipedia



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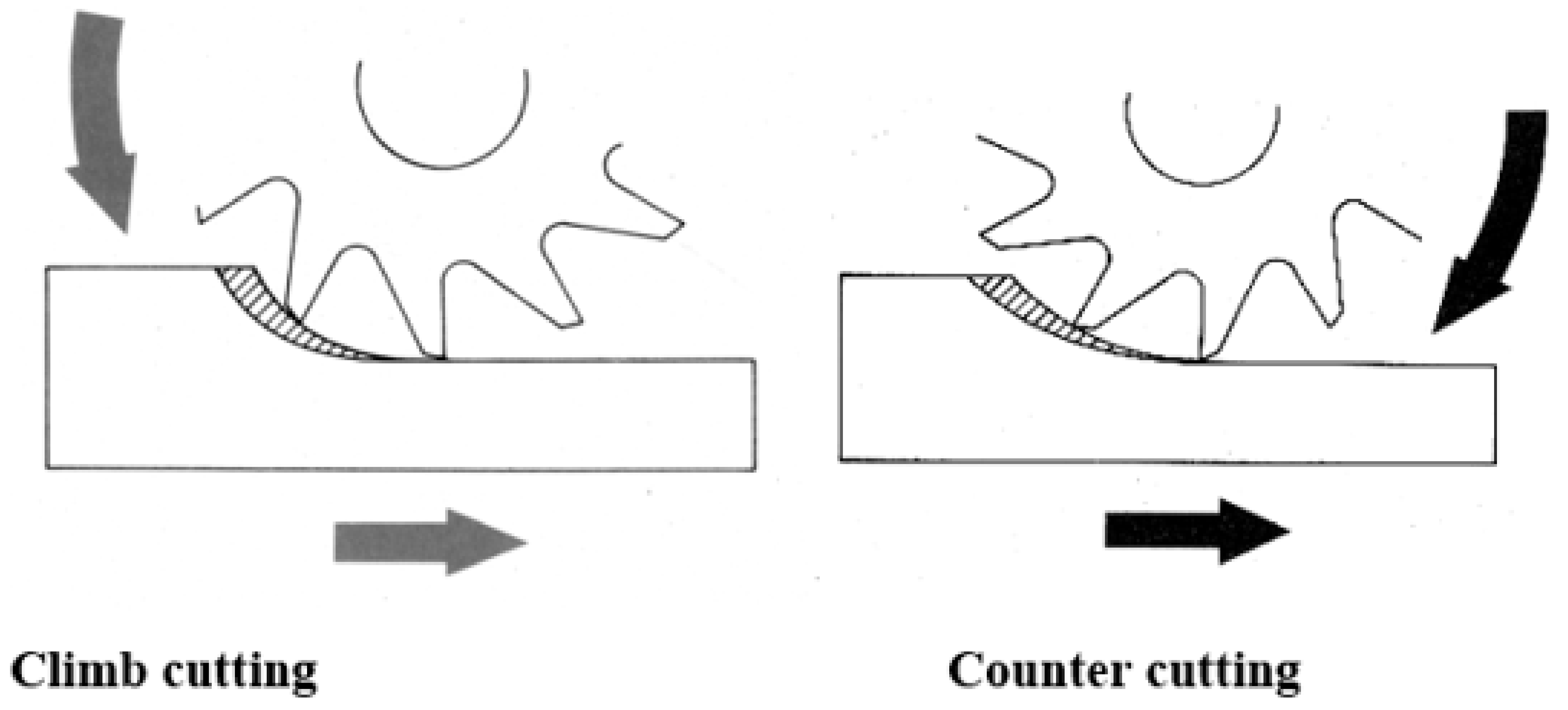
SOURCE OF VARIATION:

- **The process:** change of setting
- **Material:** raw material variation, defects
- **Equipment:** tool wear, maintenance, calibration, vibration
- **Operator:** distraction, new operator with less skill, tiredness
- **Environment:** Humidity, temperature
- **Measurement:** Capability of measurement tool

EXAMPLE:

If we change the Setup from climb to counter in a side milling operation, do we get a smaller or larger part?



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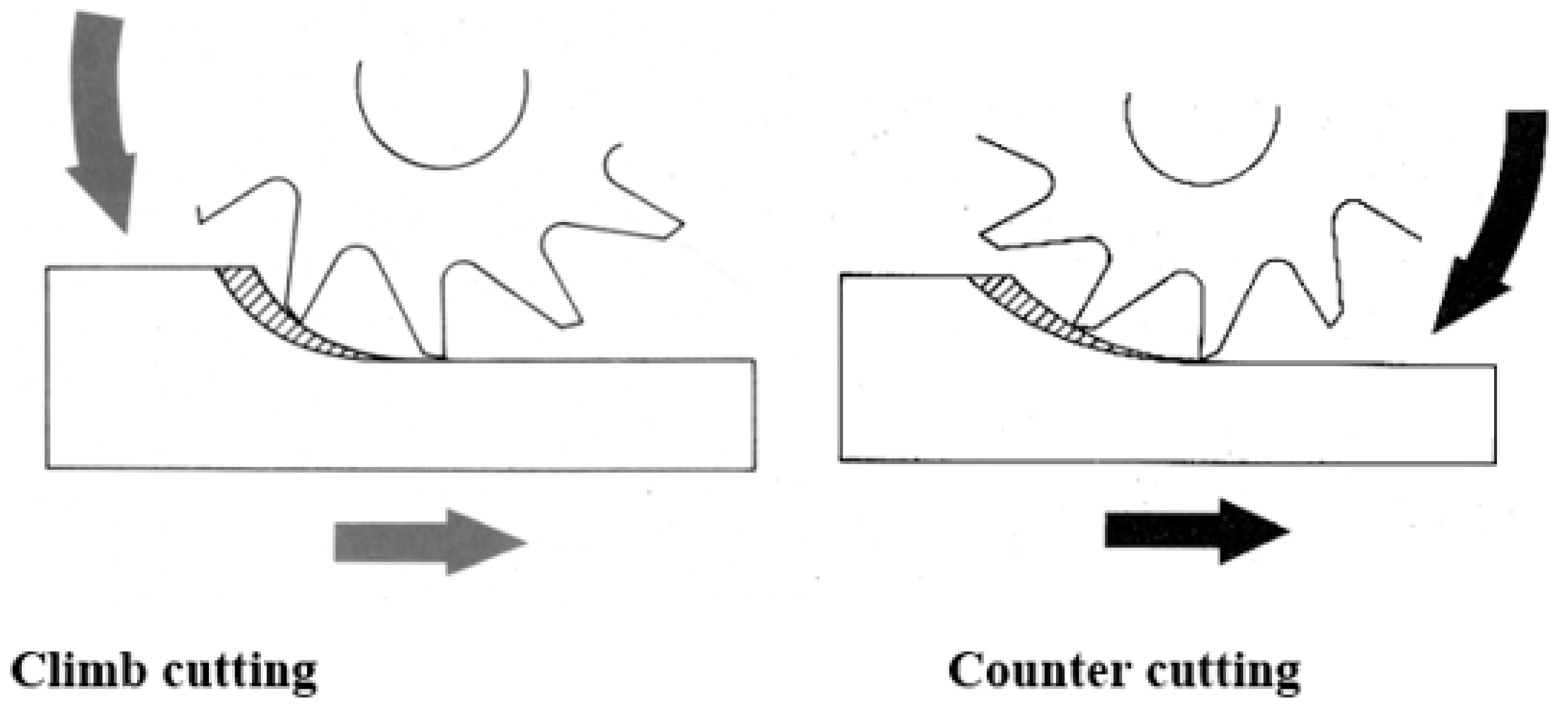
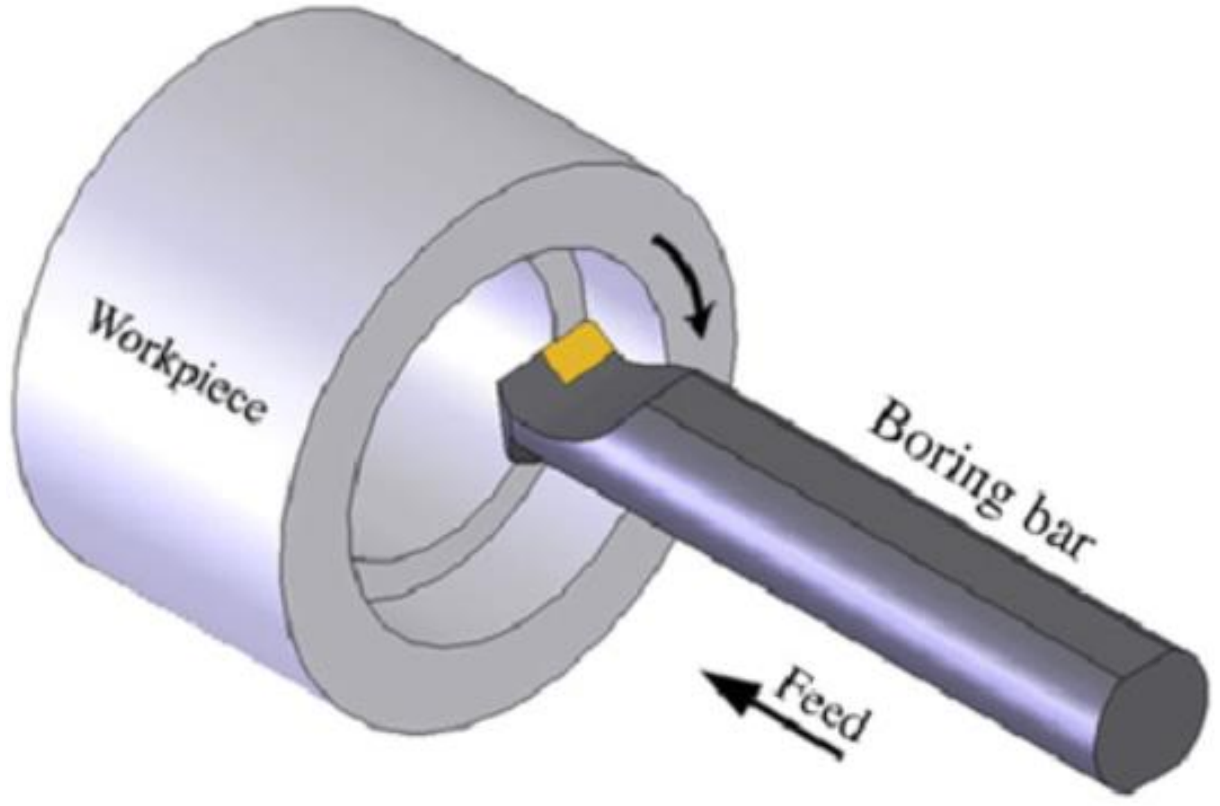


Resultant forces on the tool are bigger, so
The tool deflects more, as a result
The output dimension might be larger!

EXAMPLE:

100 parts were produced during a day-work by machining. Below is the inner diameter of the parts. What might have been gone wrong in each case?



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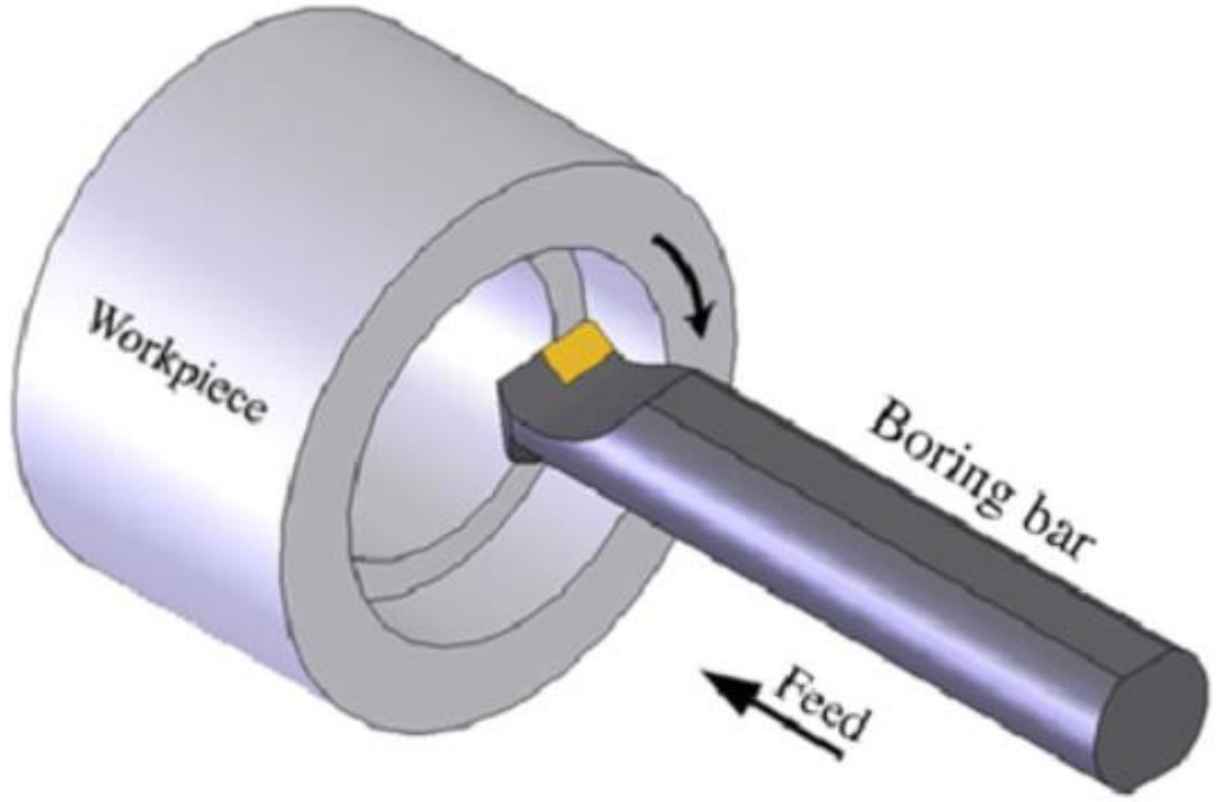
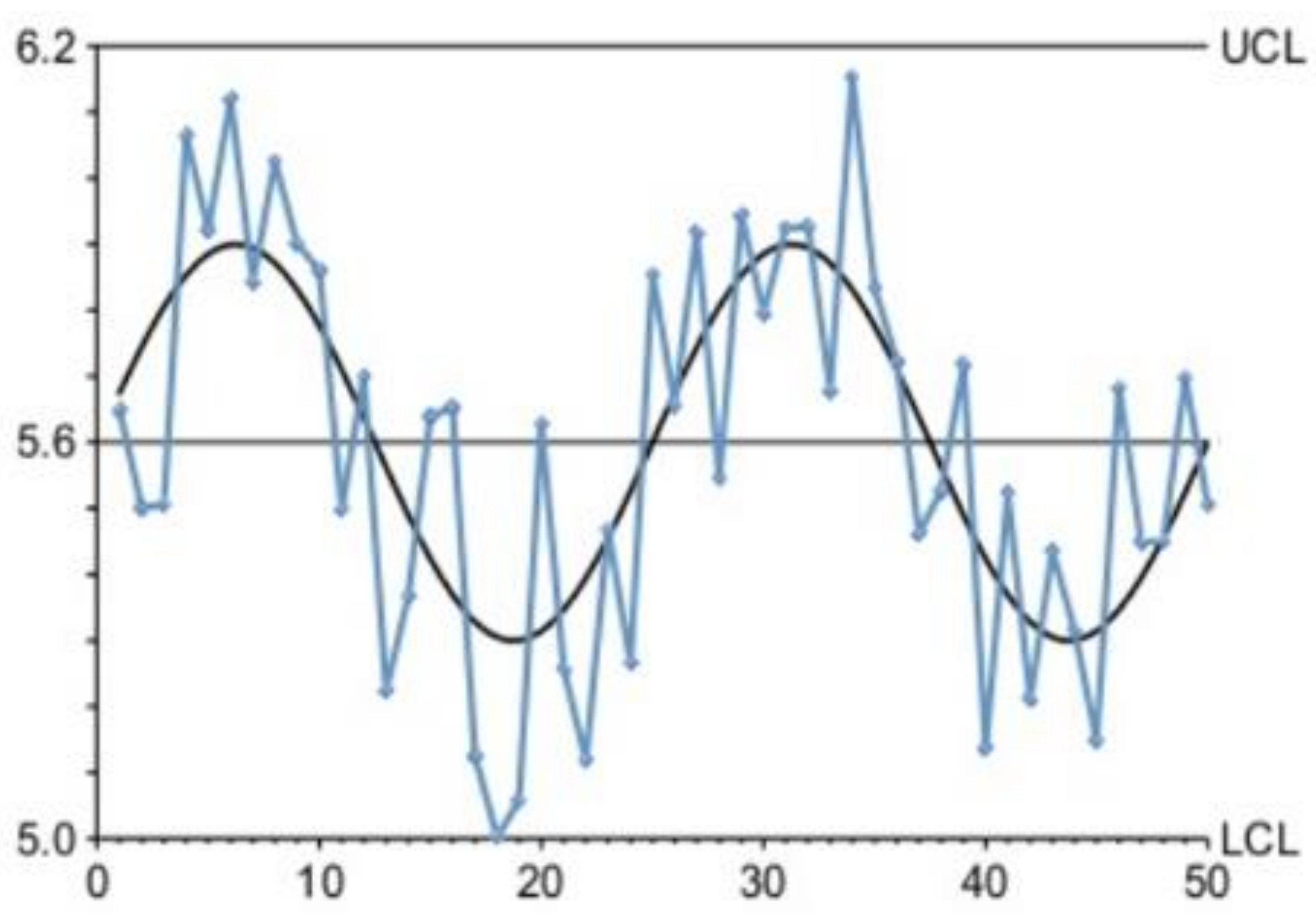


Morning Shift



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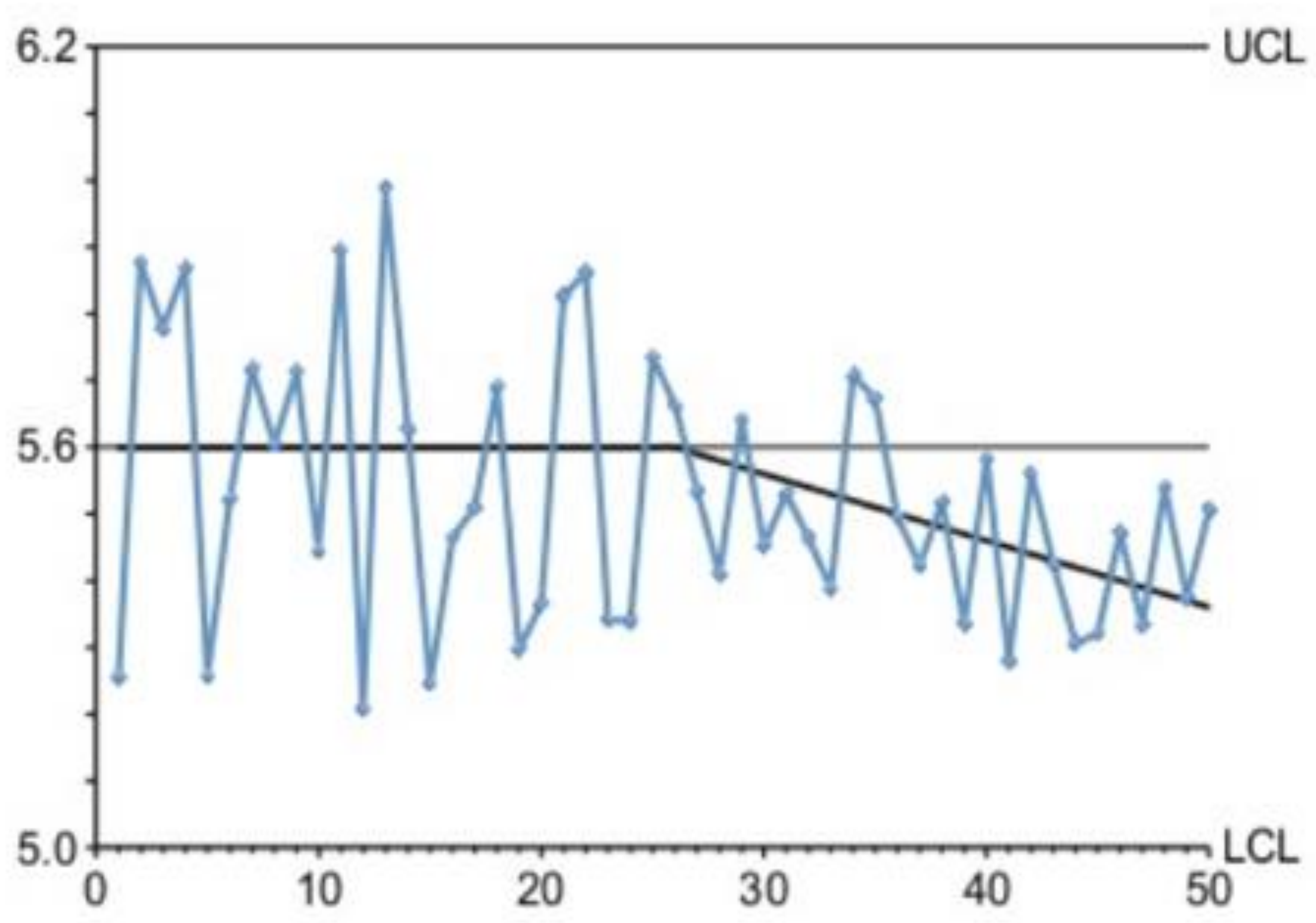

A SYSTEMATIC WAY TO QUANTIFY VARIATION:

Step 1. Choose a frequency of sampling, it depends on:

- Cost of measurement, Importance of defects, Likelihood of unexpected disturbance, Experience

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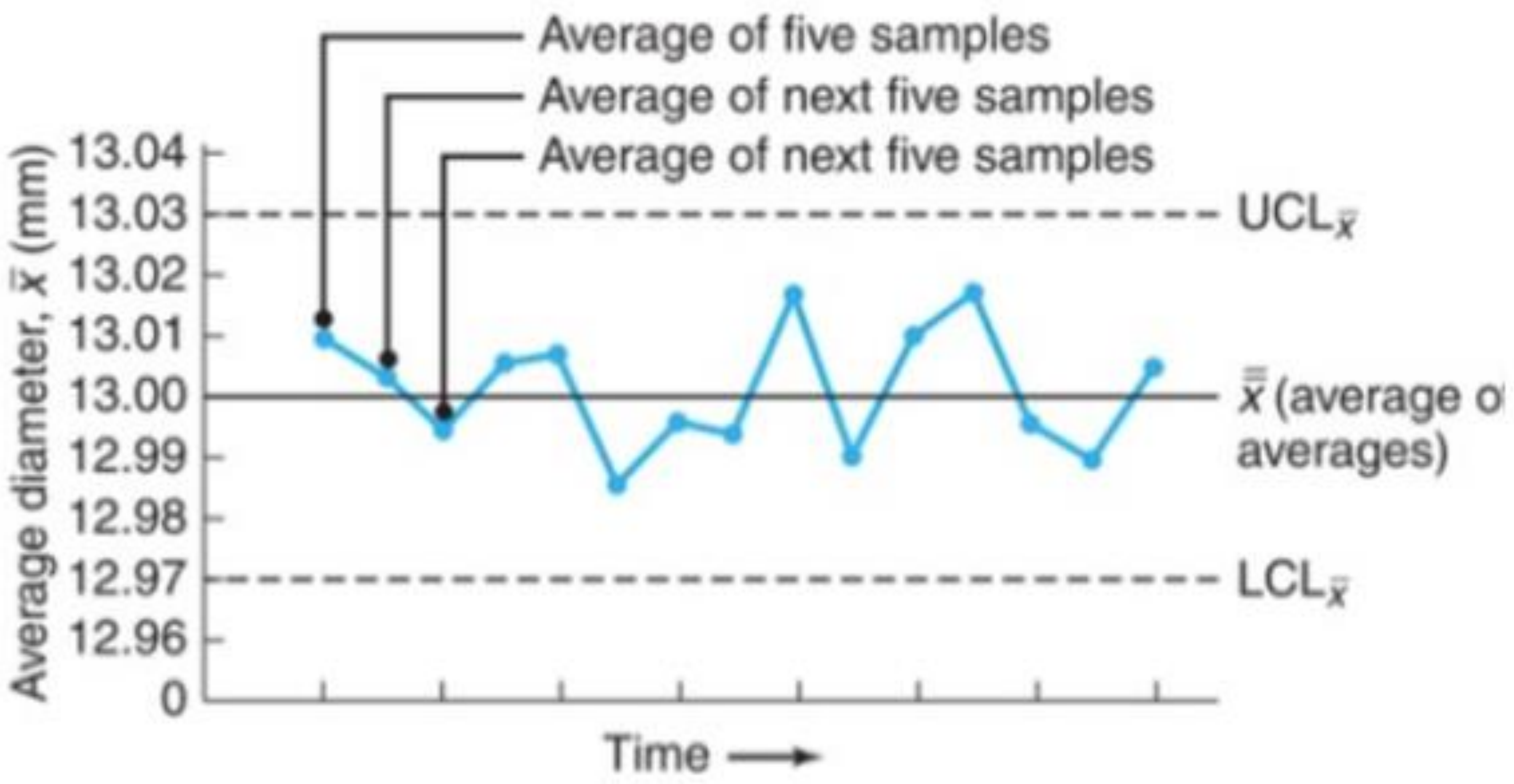

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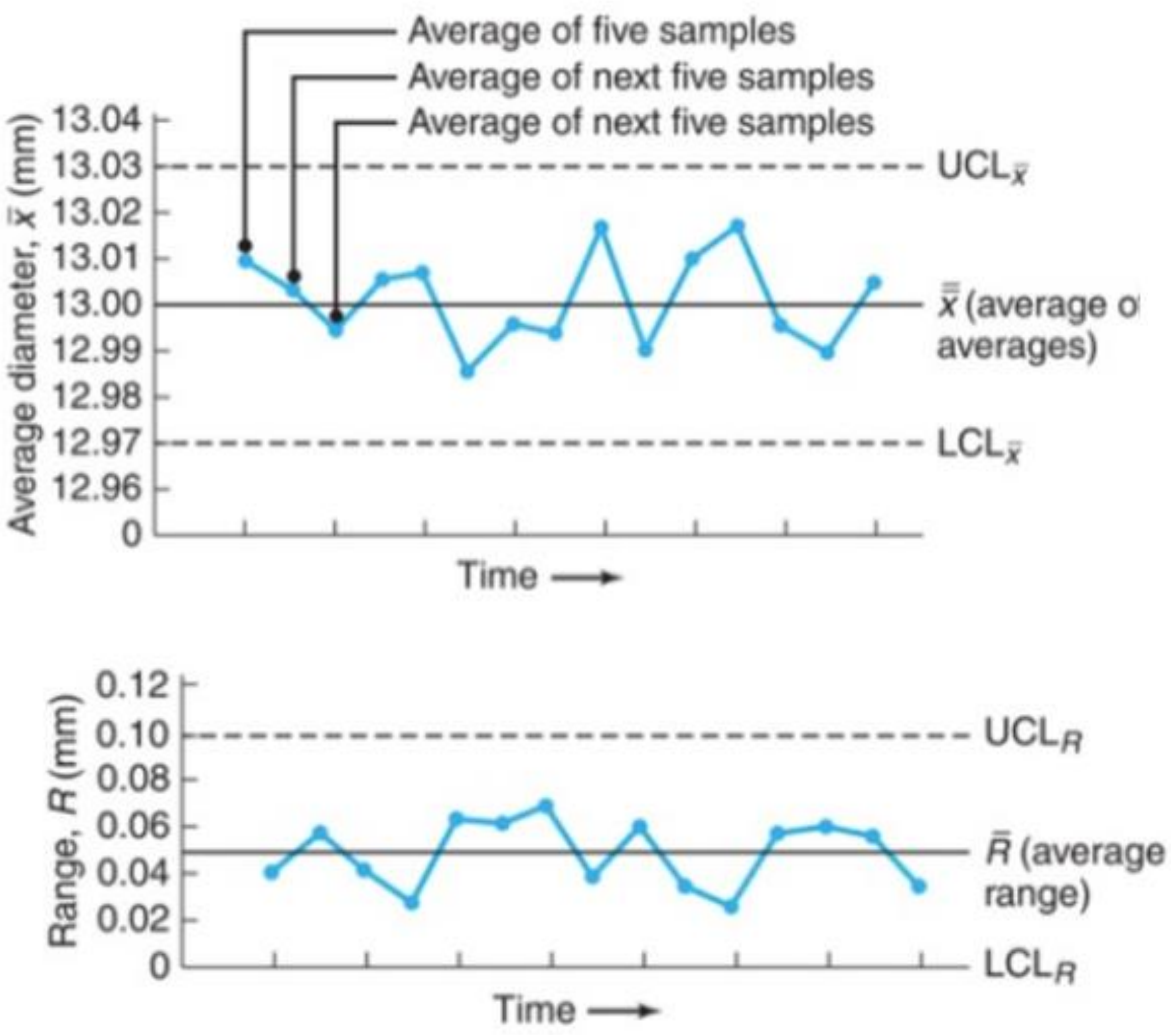

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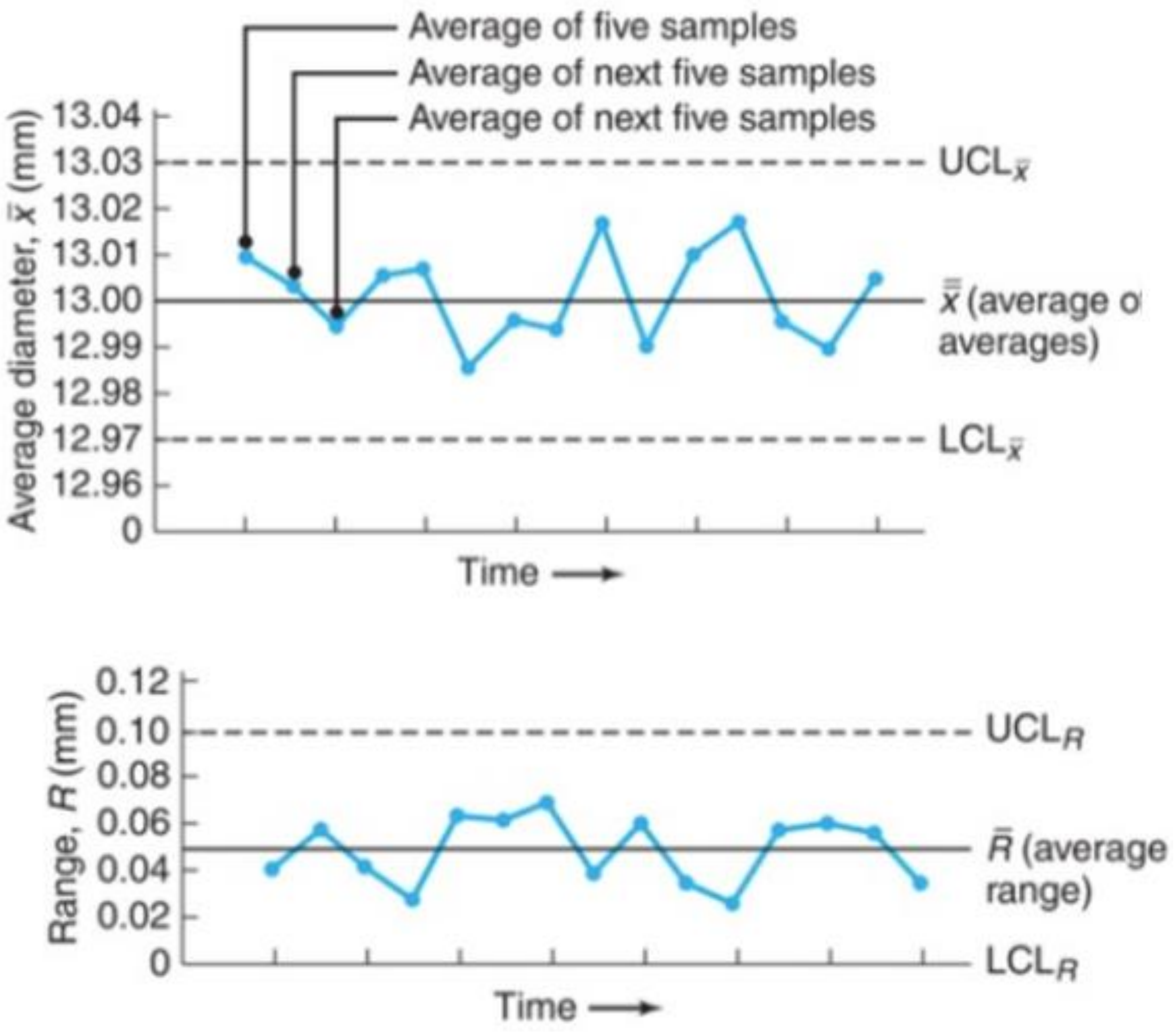

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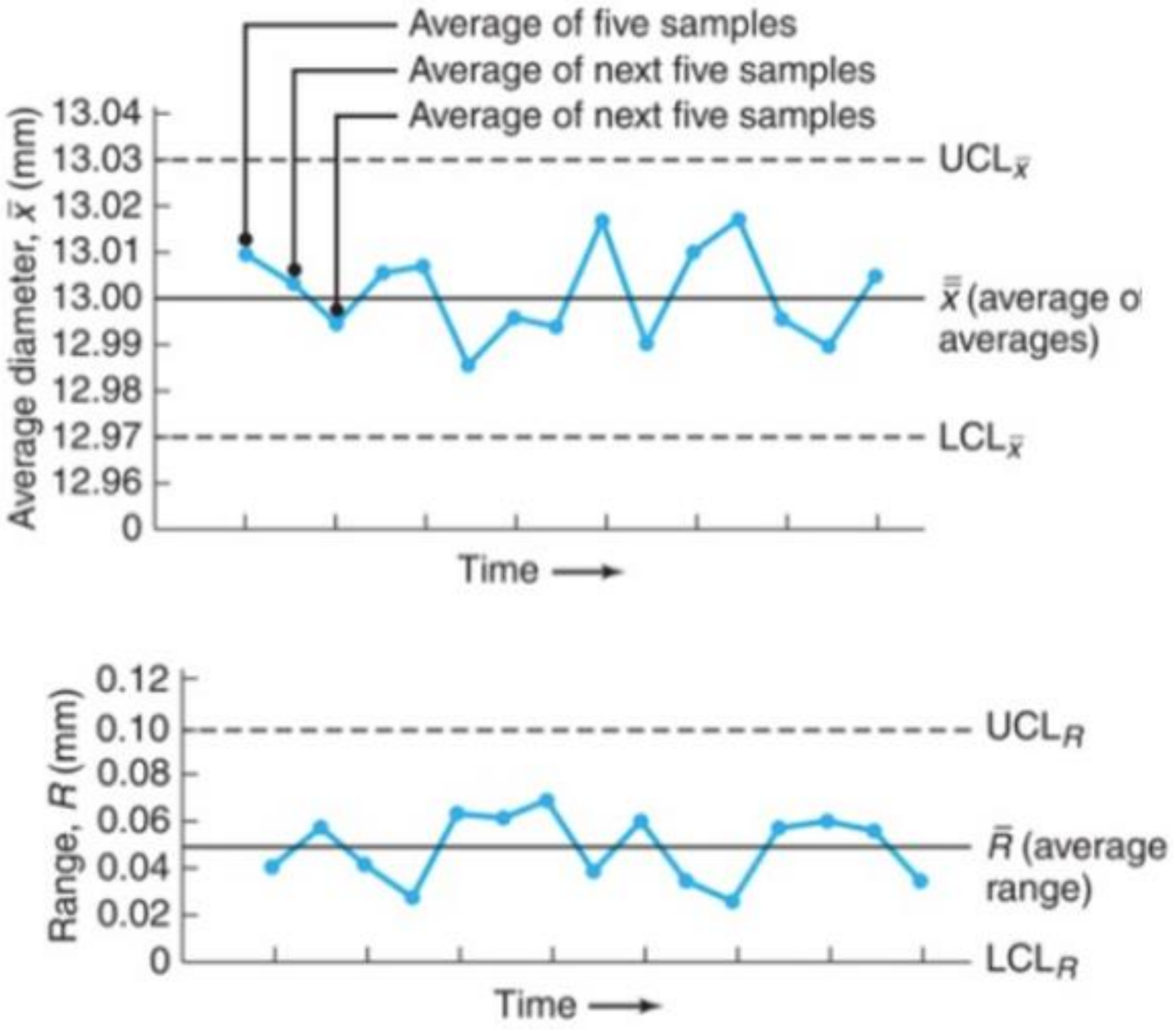

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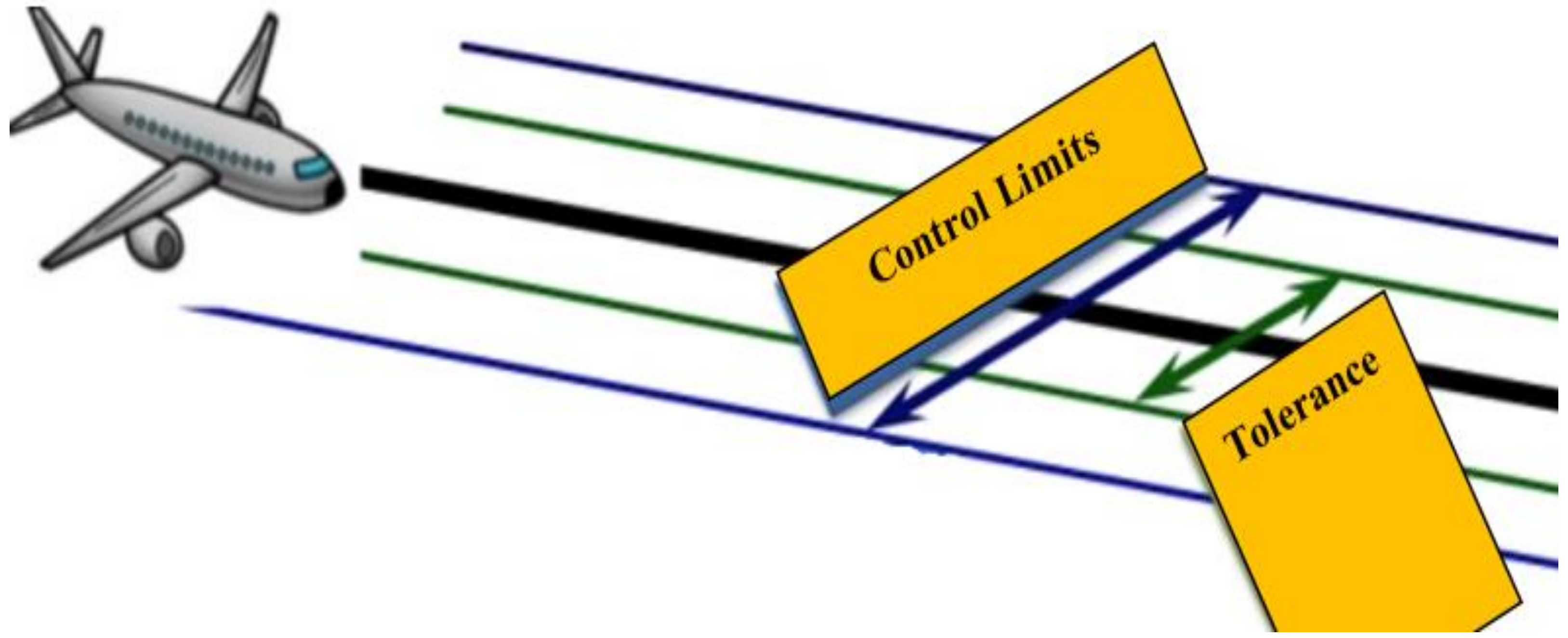
$$LCL = \bar{\bar{X}} - A_2 \bar{R}$$

$$UCL = \bar{\bar{X}} + A_2 \bar{R}$$

PROCESS CAPABILITY:



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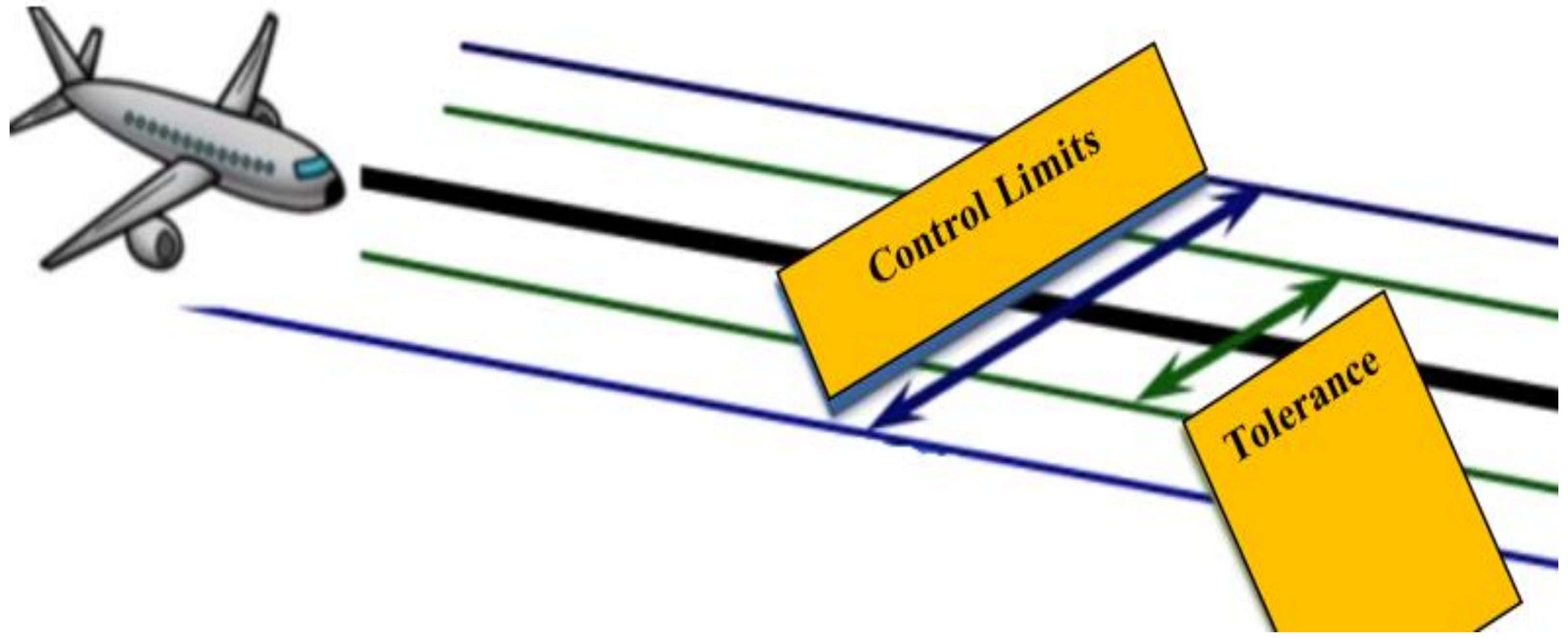

A process capability index is defined by:

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

Setting C_p is not an easy task! It depends on judging what is good enough!

Also, it depends on the knowledge of the "cost of defects" in our product.

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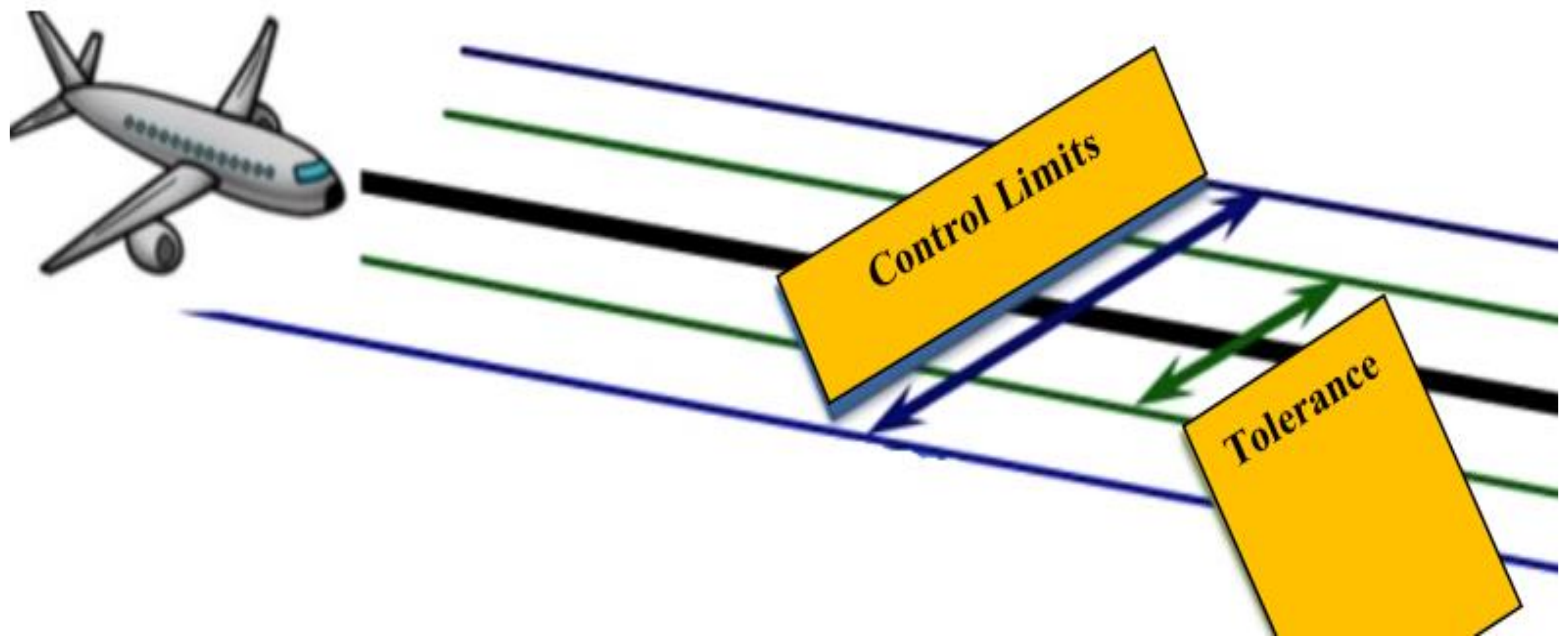

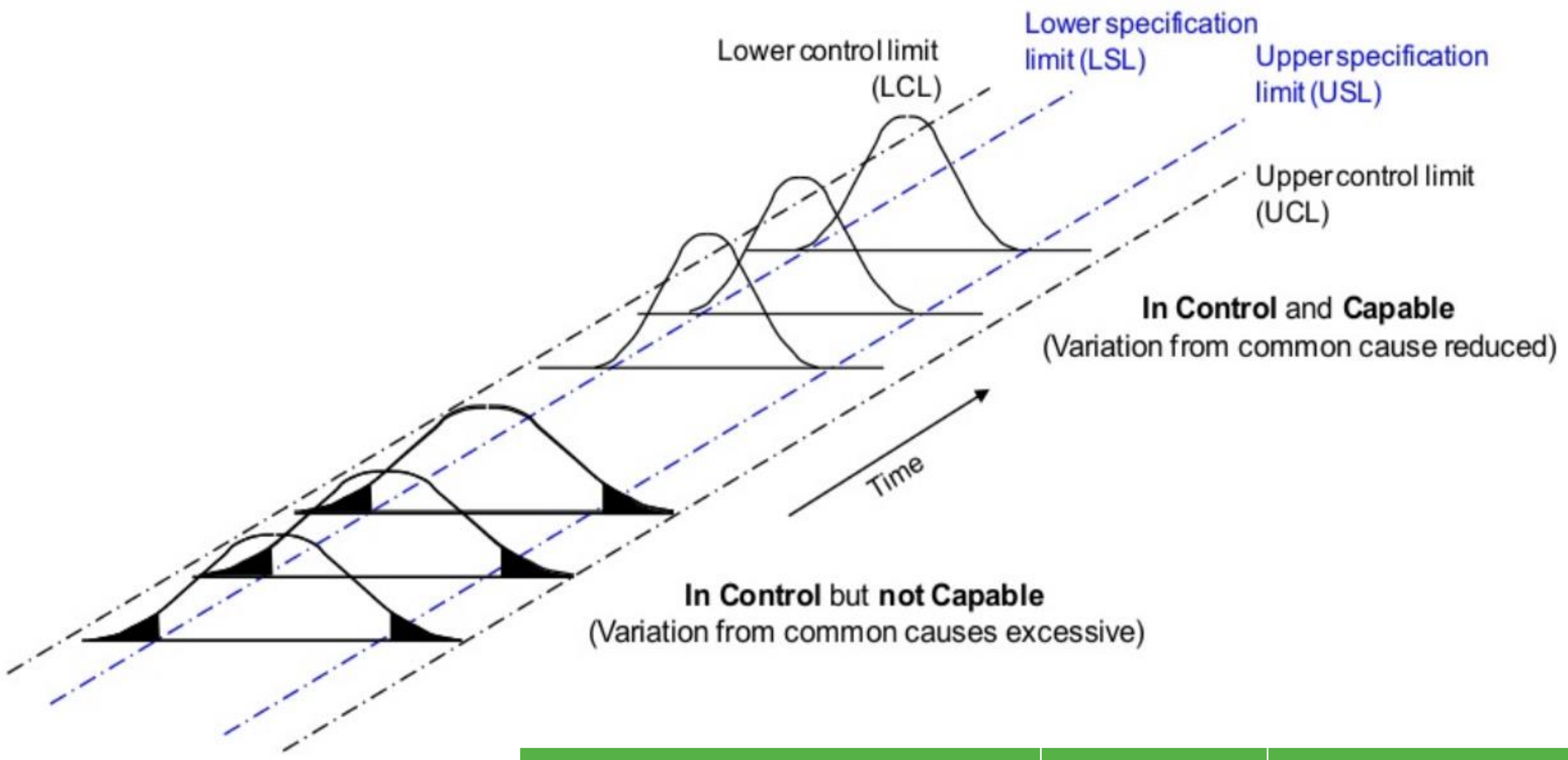

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	Recommended C_p	Defects/1000000
Existing process (Okay)	1.33	63
New process (Improved)	1.5	8
Parts which safety is critical	1.67	6
Absolute Quality	2	3.4

DEFECTS IN TERMS OF NUMBER OF STANDARD DEVIATIONS:

Standard Deviation	C_p	Defective Parts/1000000
$\pm 1\sigma$	0.333	317400
$\pm 2\sigma$	0.667	45600
$\pm 3\sigma$	1.333	63
$\pm 4\sigma$	1.5	8
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Traditional

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$\pm 6\sigma$	2	3.4	← Six-Sigma Quality

SIX-SIGMA

Philosophy:

- Anything less than ideal is an opportunity for improvement.
- Defects costs money.
- Identify the root causes of performance deficiencies.
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Approach:

Define the problem (the defects in any process must be measurable)

Measure the defect (the defects must be quantified)

Analyze the data (the cause will be identified)

Improve the process to eliminate the defect

Control and sustain the improvement

Known as **DMAIC approach.**

KAIZEN METHODOLOGY

改善

“Change for the better”

KAIZEN METHODOLOGY

改善

"Change for the better"

- Good processes bring good results.
- Go see for yourself to grasp the current situation.
- Speak with data, manage by facts.
- Take action to contain and correct root causes of problems.
- Work as a team
- KAIZEN is everybody's business
- Big results come from many small changes accumulated over time

LEAN MANUFACTURING

Lean thinking or ***Lean manufacturing*** strategy was invented by Toyota, known as T.P.S. (Toyota Production System)

based on these principles:

- Only make what we need, when we need it.
- Remove waste
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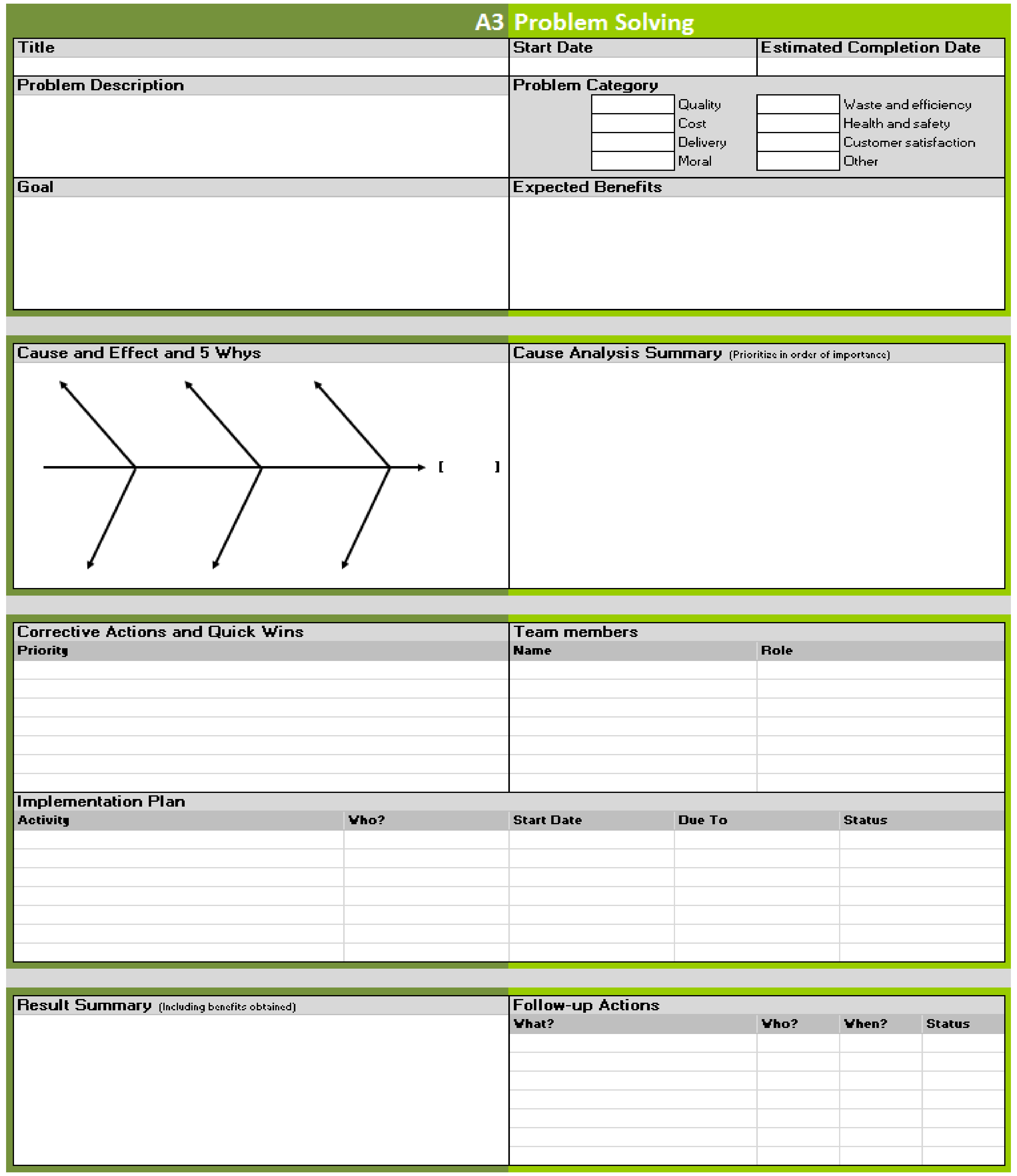
Philosophy:

- Slow but consistent.
- Small improvements.
- Never settle for good.
- Persistence in elimination of waste.
- Eliminate any activity that adds no real value to the product.
- Respect for employee.
- Go and see what is happening at the place the work is done.
- Fail better (willing to try and fail from time to time)

LEAN TOOLS

- **5S** (Sort, Straighten, Shine, Standardize, Sustain)
- **Cellular Manufacturing**
- **Andon Lamps**
- **A3 thinking**
- **3P (**Production Preparation Process), What, How, Why
- **Water Spider**
- **Kanban** (pull systems),
- **Poka-Yoke** (error-proofing)
- **TPM** (Total Productive Maintenance)


A3 Problem Solving

Title | Start Date | Estimated Completion Date

Problem Description | Problem Category: Quality, Cost, Delivery, Moral, Waste and efficiency, Health and safety, Customer satisfaction, Other

Goal | Expected Benefits

Cause and Effect and 5 Whys | Cause Analysis Summary (Prioritize in order of importance)

Corrective Actions and Quick Wins — Priority | Team members — Name, Role

Implementation Plan — Activity, Who?, Start Date, Due To, Status

Result Summary (Including benefits obtained) | Follow-up Actions — What?, Who?, When?, Status