# Module 6:

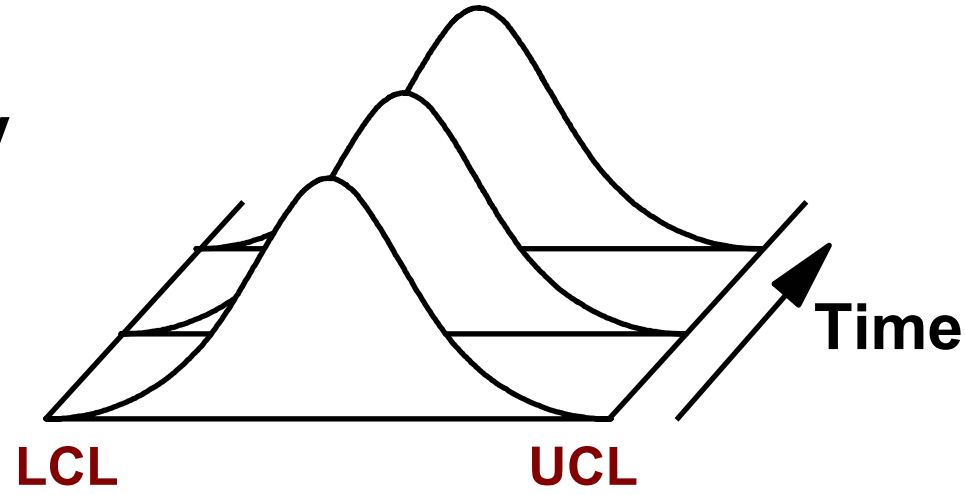
## Assessing Process Capability

# Objectives

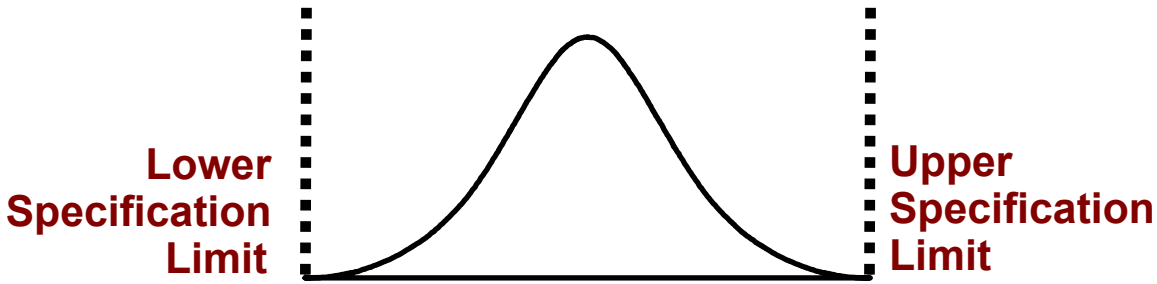
- Assess process capability
  - Definition
  - Relation to process stability
- Use histograms to depict process capability
  - Construction
  - Relation to specifications
- Compare Natural Process Limits with Specifications
  - Calculate specified tolerance in *Sigma Units*
  - Calculate the Distance to Nearest Specification (DNS)
- Explain the Taguchi Loss Function

# Process Capability

- **Process stability**




- **Conformity to specifications**



# Assessing Process Capability

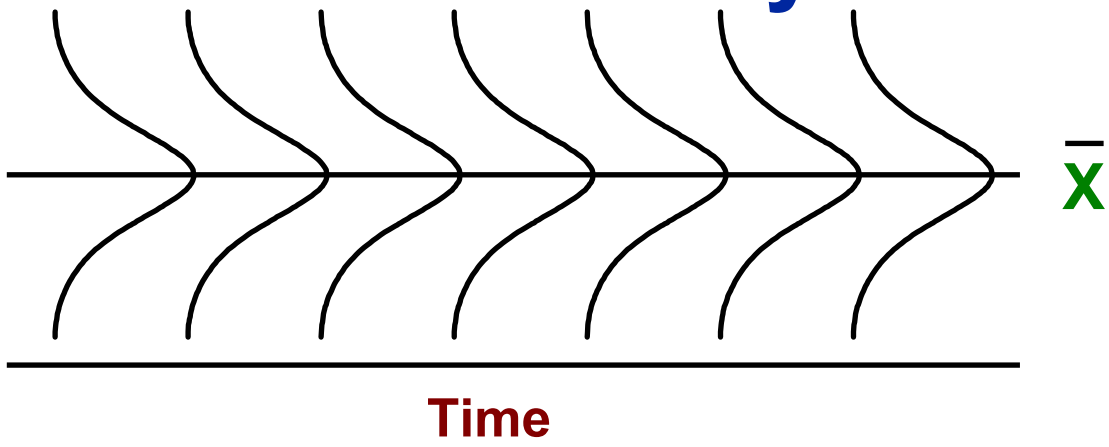
- Individuals Chart
  - Center line and upper or lower control limit estimate capability
- Averages Chart
  - Compares natural process distribution to specification limits
  - Determines, mathematically, the proportion of observations in or out of specifications
  - Develops indices that reflect the spread of and how centered the natural process limits are within the specification limits

# Comparing Stability and Conformance to Specifications

| Conformance to Specifications | Stability (In statistical control): Yes | Stability (In statistical control): No |
|---|---|---|
| Yes | 1. Ideal State<br>Capable | 3. Brink of Chaos<br>Not stable, but within specifications (at least temporarily). Will "drift" out of specifications. |
| No | 2. Threshold State<br>Stable, not capable | 4. Chaos<br>Not stable, not capable |

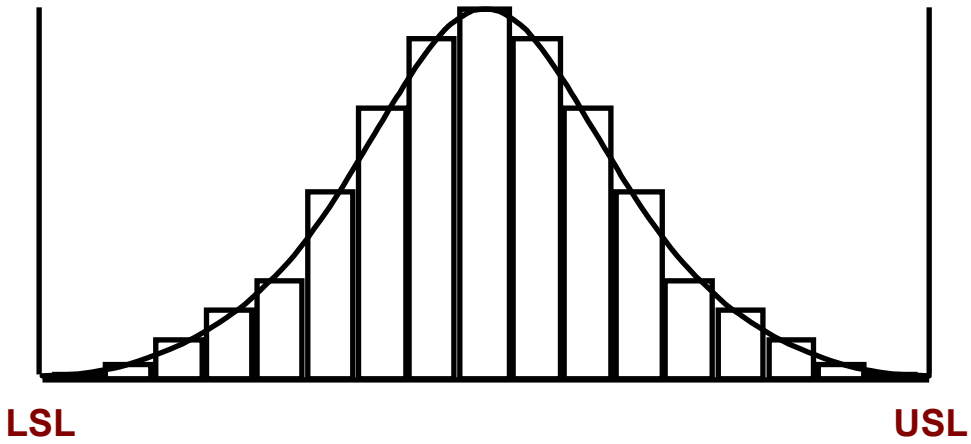
(from Wheeler & Chambers, 1992)

# Process Capability Requires Process Stability



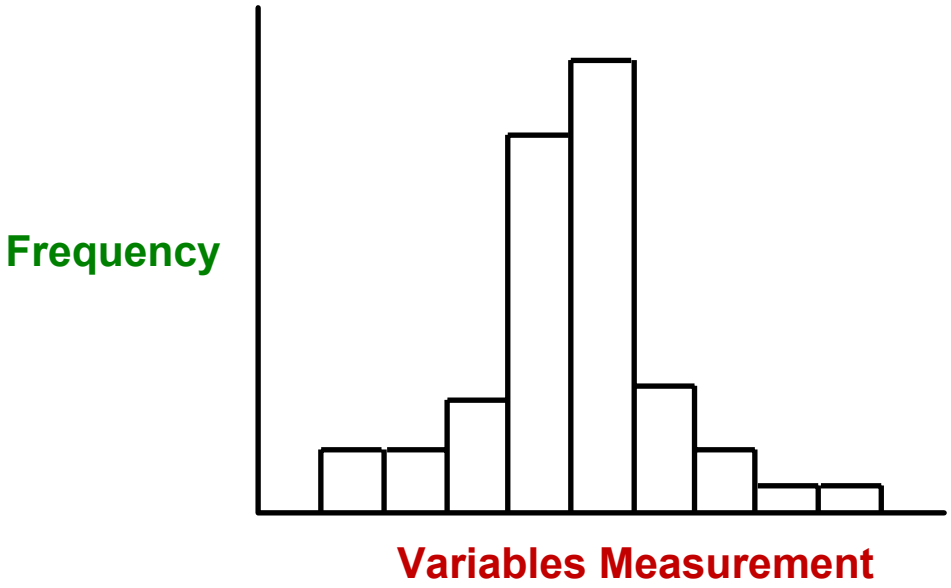

- **Process Stability**
  - **Time-dependent**
  - **Order of data is important**
  - **Prediction of future performance in relation to past performance**

# A Histogram:




- A Picture of Process Capability
  - Time Independent
  - Order of data not important
  - Picture of process output's relationship to specification limits

# What is a Histogram?

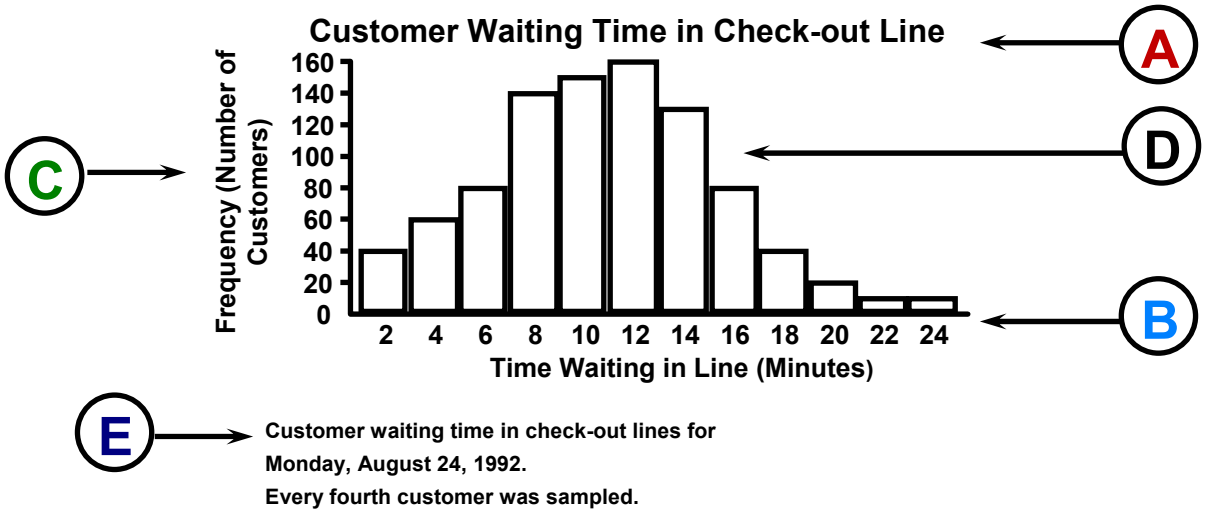



- Vertical bar graph that shows the distribution of variables data
- Graphic summary of the frequency of occurrence of specific observations for a set of variables data

# Why are Histograms Used?

- Histograms compare individual process results with specification limits
- Histograms summarize large data sets
- Histograms are useful in communicating information
- Histograms can lead to the identification of factors affecting processes

# What are the Elements of a Histogram?




A. Title

B. Horizontal or X-Axis (measurements)

C. Vertical or Y-Axis (counts or percentages)

D. Bars (counts of specific measurements)

E. Legend

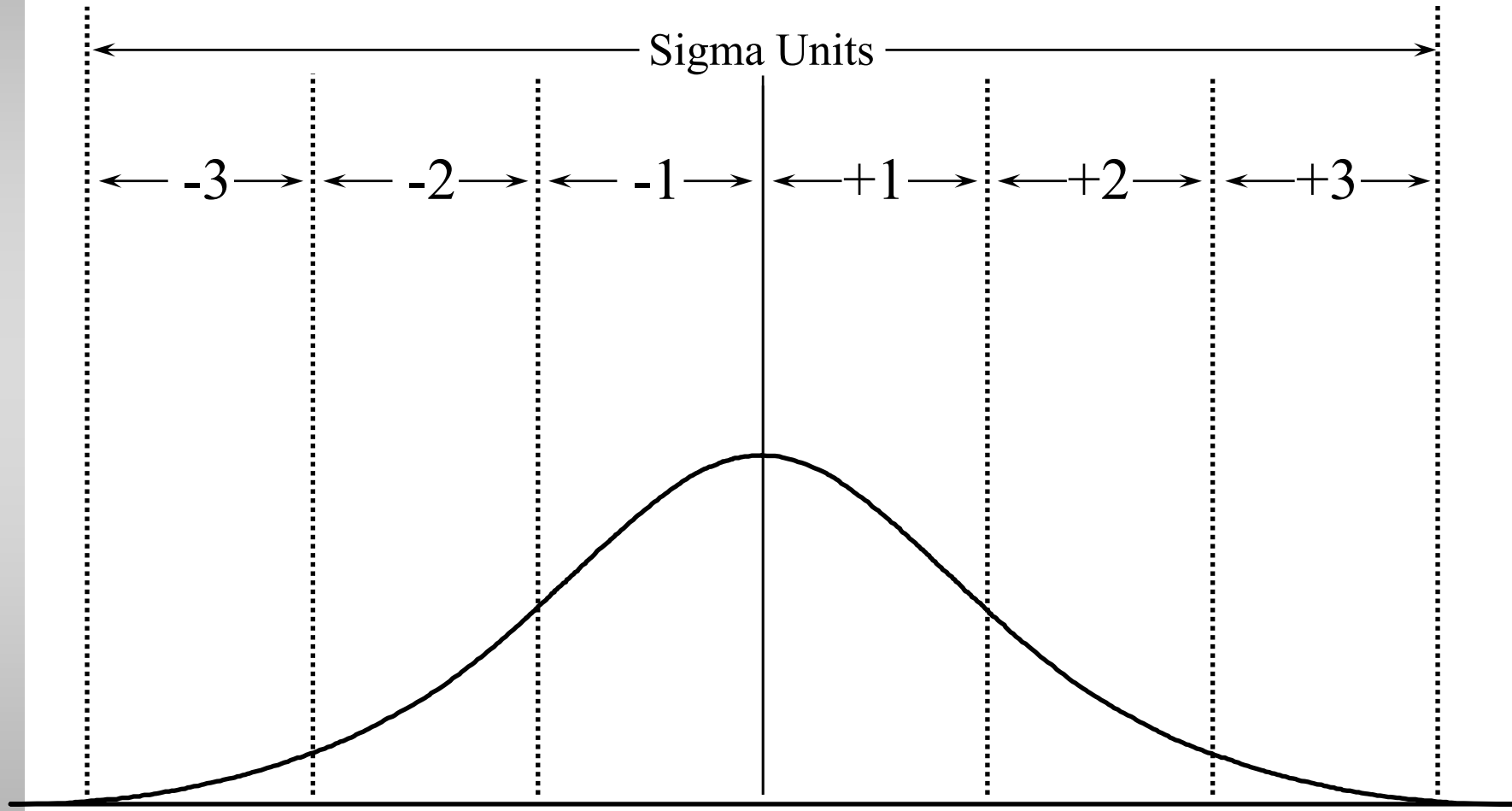
# How to Construct a Histogram

- 1. Collect and record appropriate data
- 2. Summarize data in a frequency distribution
- 3. Group data into intervals
- 4. Transform data into graphic form: a histogram
- 5. Add a title and a legend

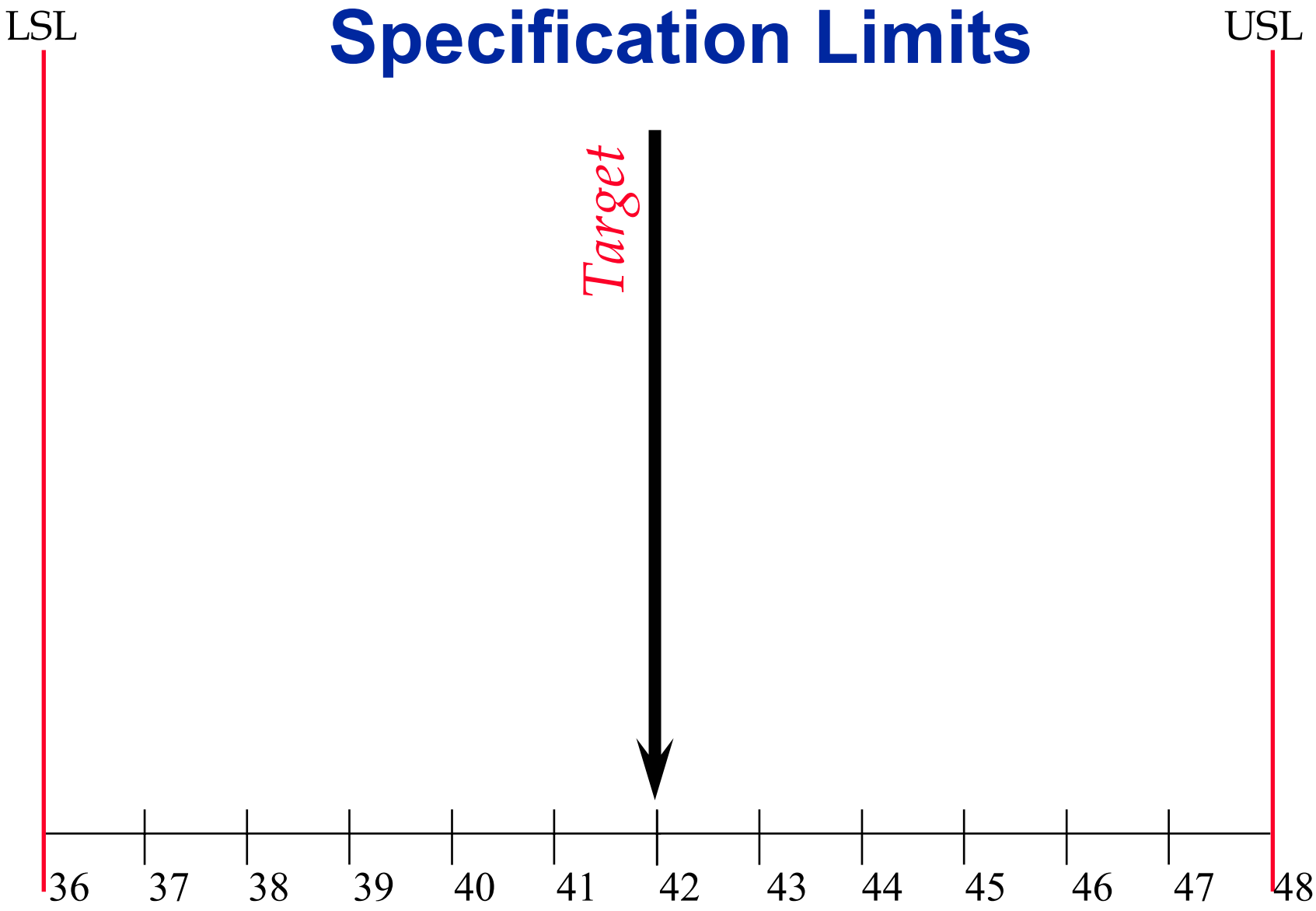
# Expressing Capability

- **Specifications expressed in terms of *Sigma Units***
  - **Desired: Specification limits > 6 *sigma units* wide**
- ***DNS* - distance to nearest specification**
  - **Desired: DNS 3 *sigma* or greater**

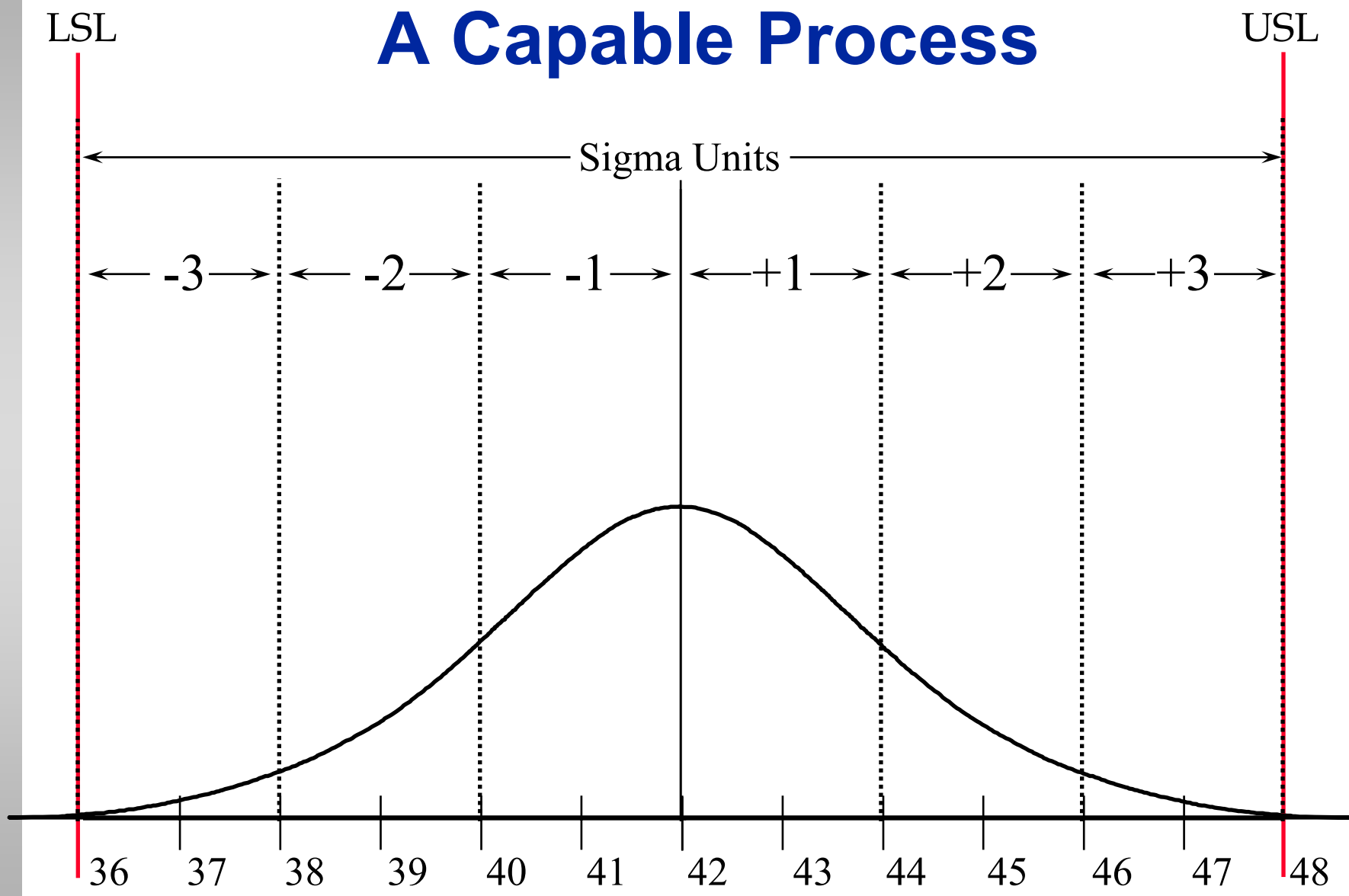
# A Process



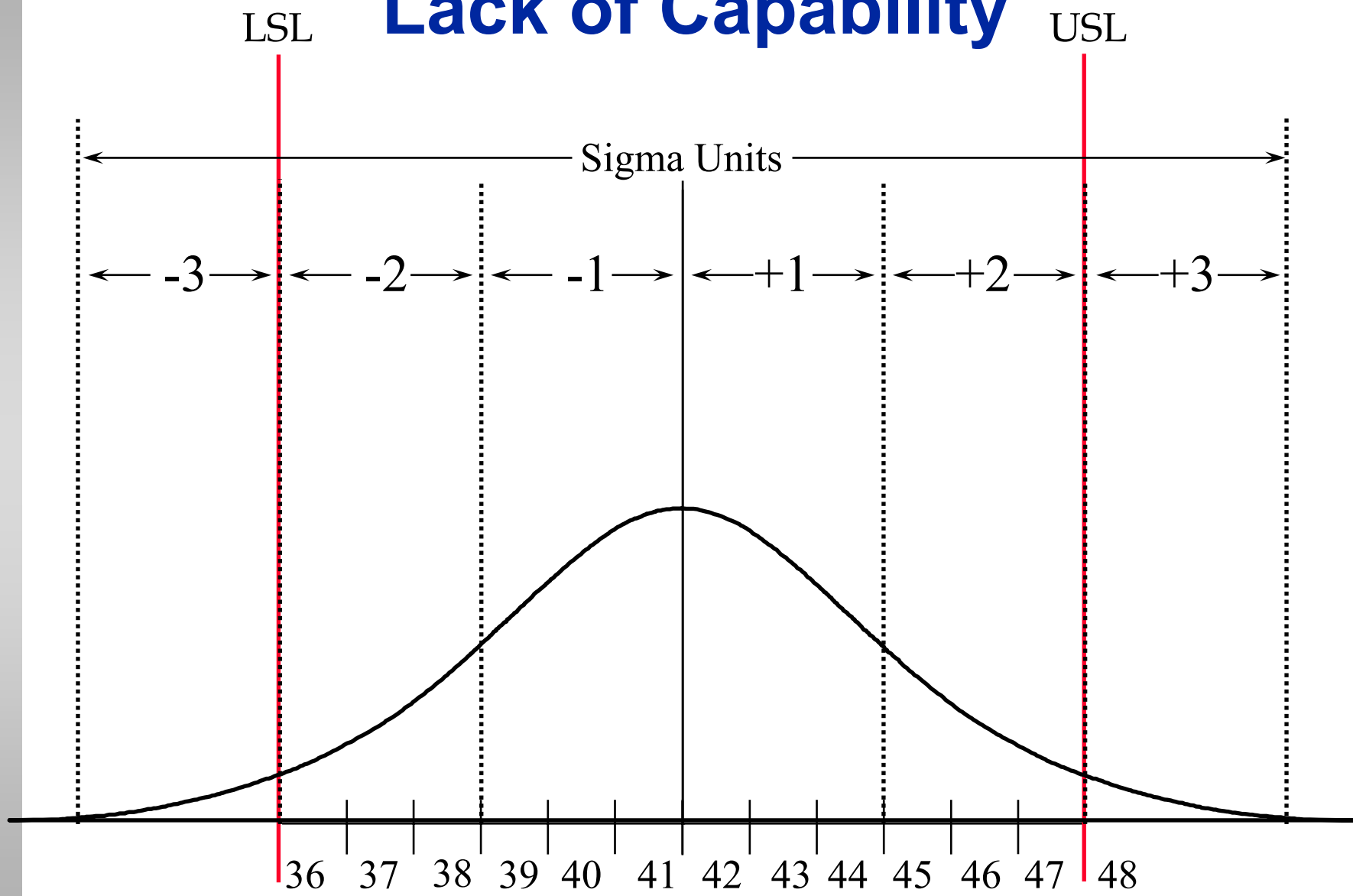
# Specification Limits



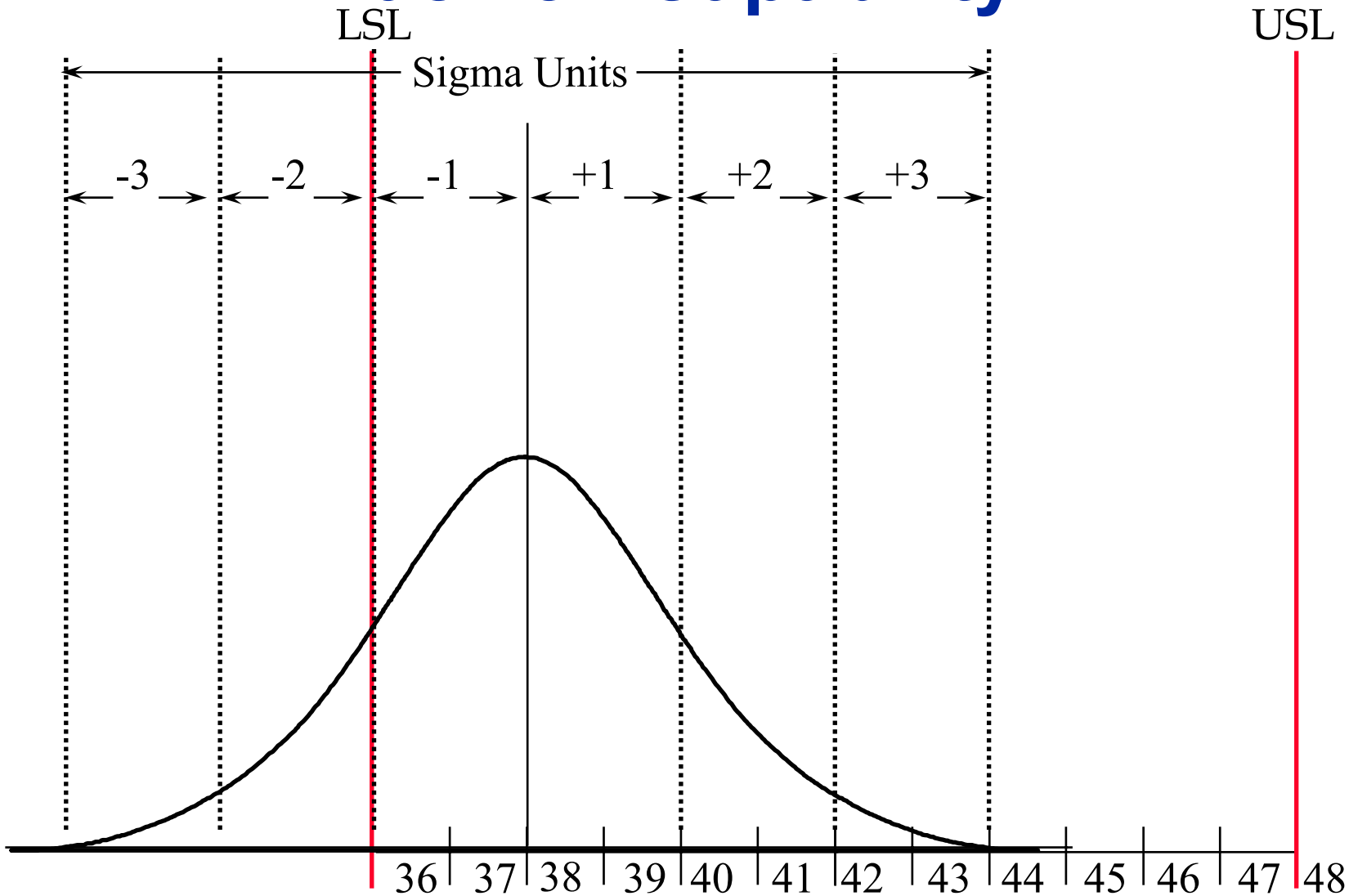
# A Capable Process

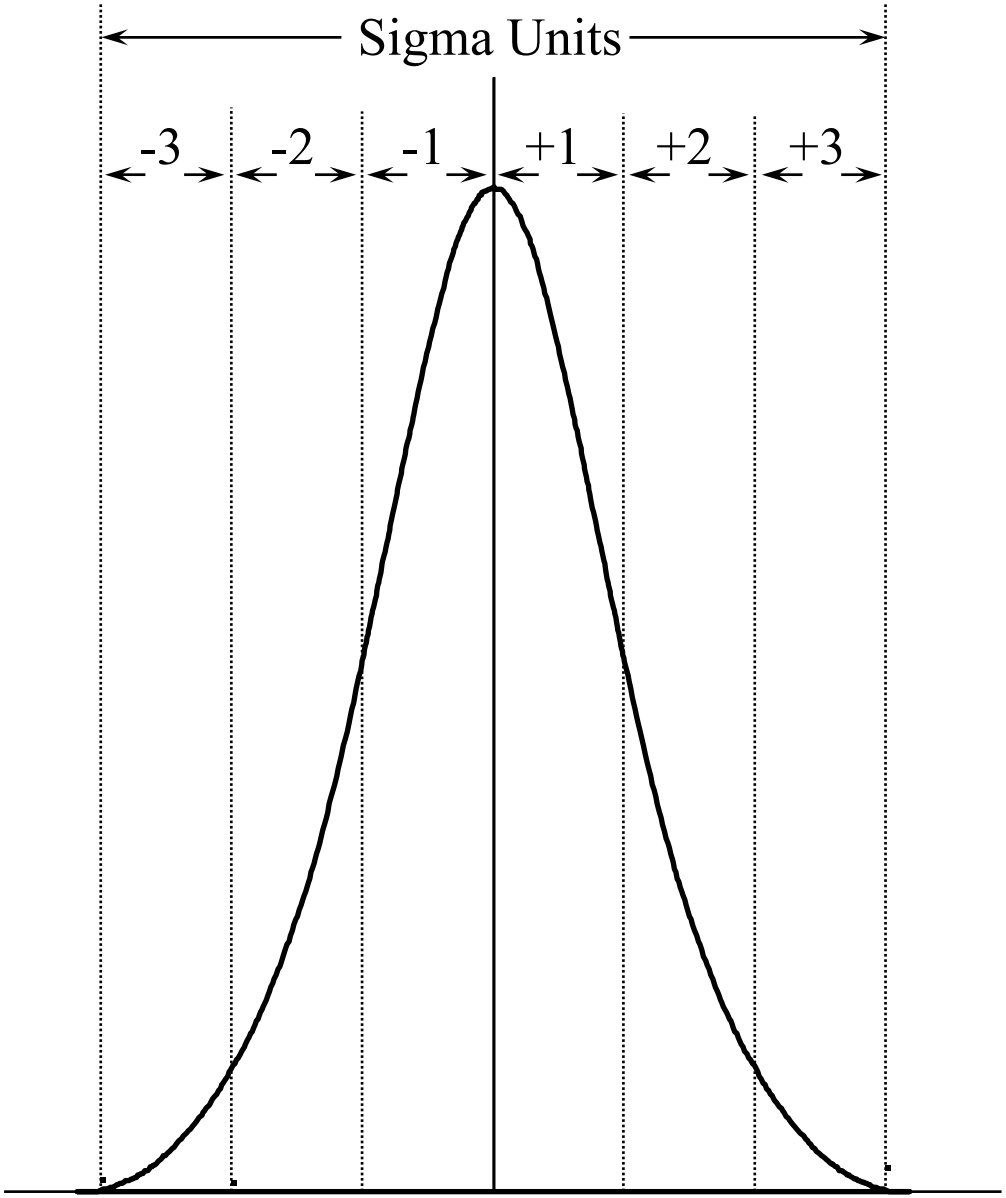


# Lack of Capability



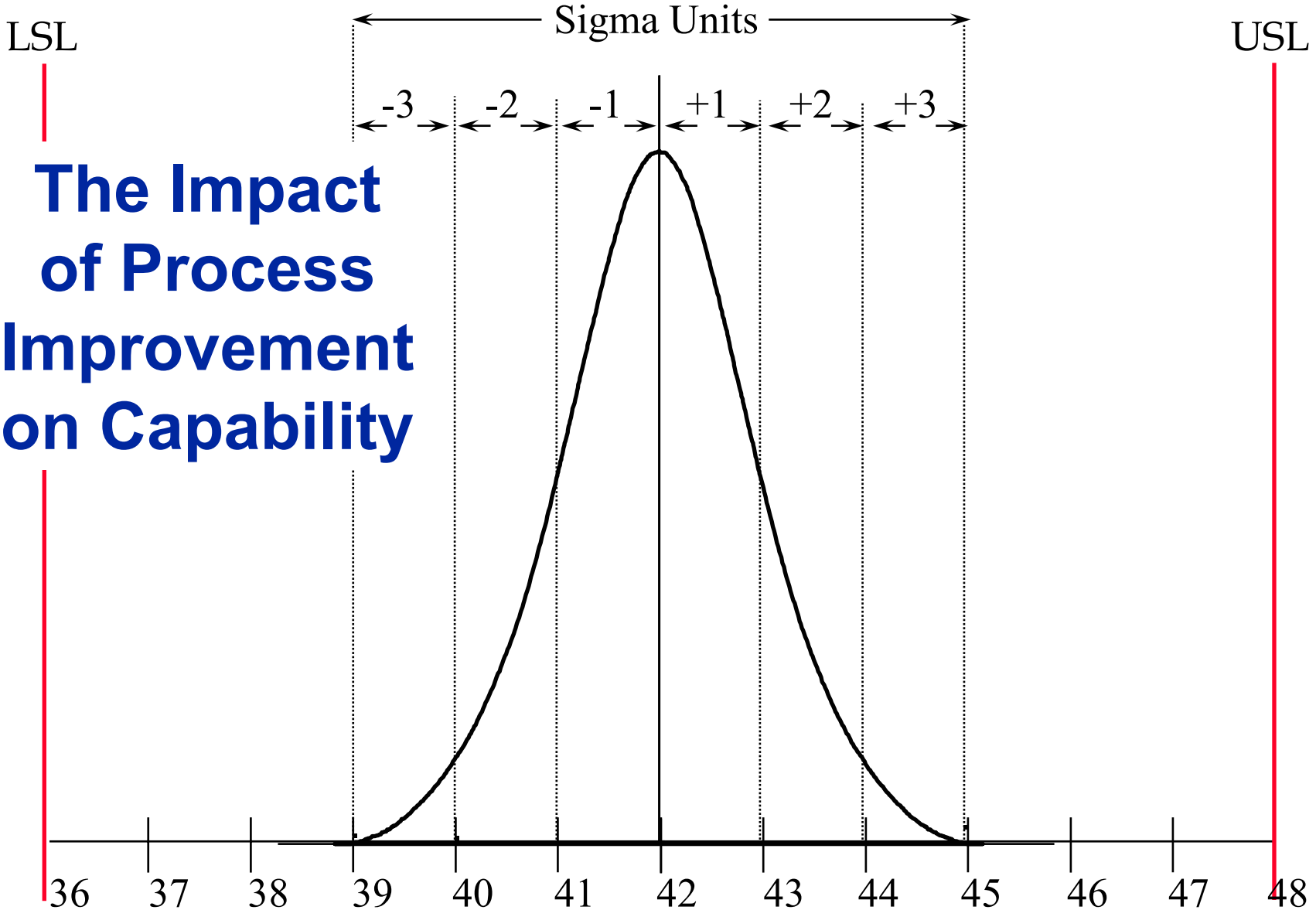
# Lack of Capability



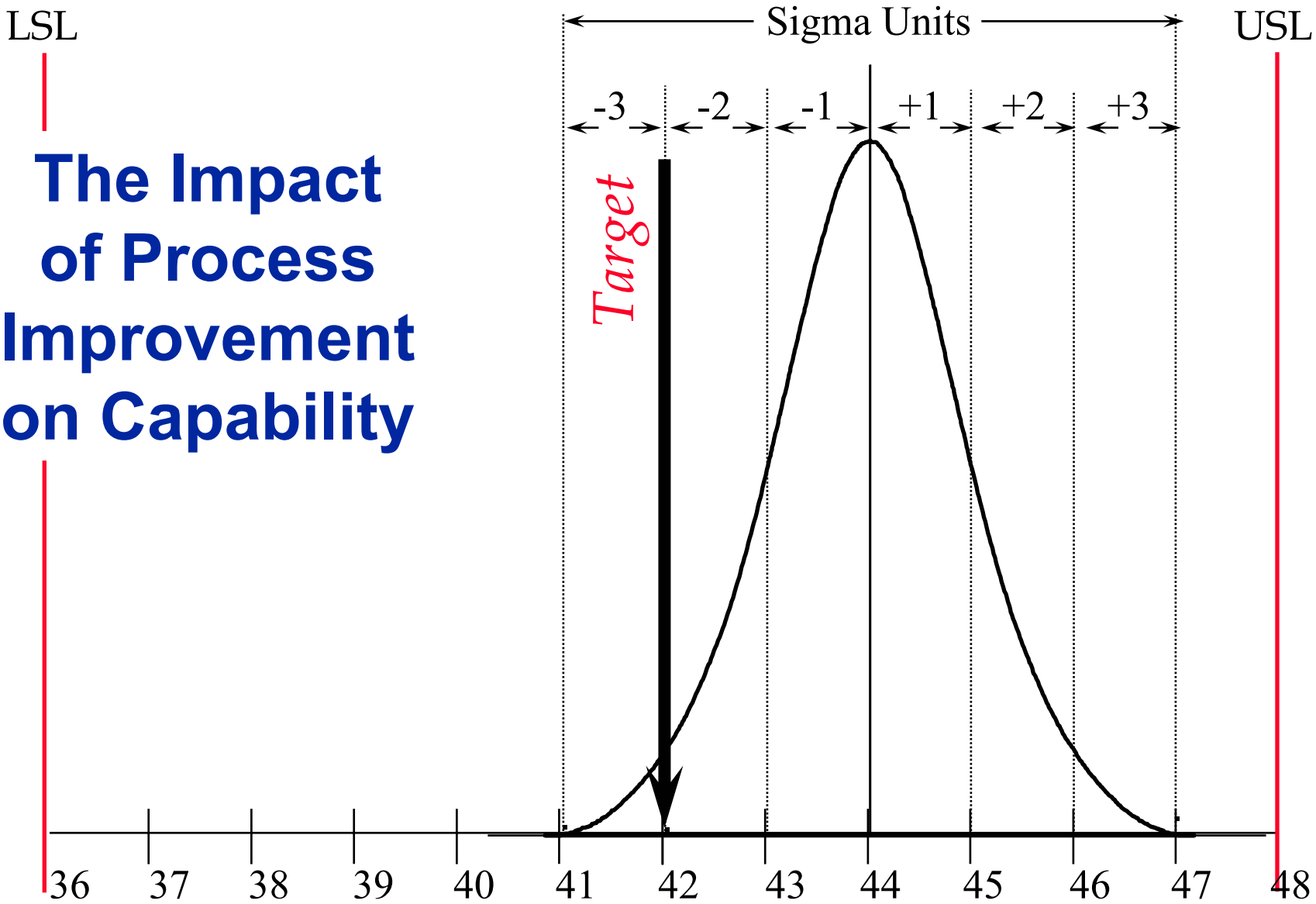



# An Improved Process

# The Impact of Process Improvement on Capability



# The Impact of Process Improvement on Capability



# Capability Calculations

- **Estimate One Sigma:**
  - $Sigma(X) = \bar{R}/d_2$
- **Find Specification Width:**
  - $USL - LSL$
- **Find Specified Tolerance in *sigma units:***
  - $$\frac{USL - LSL}{Sigma(X)}$$

# Find DNS, the Distance to Nearest Specification (in Sigma Units)

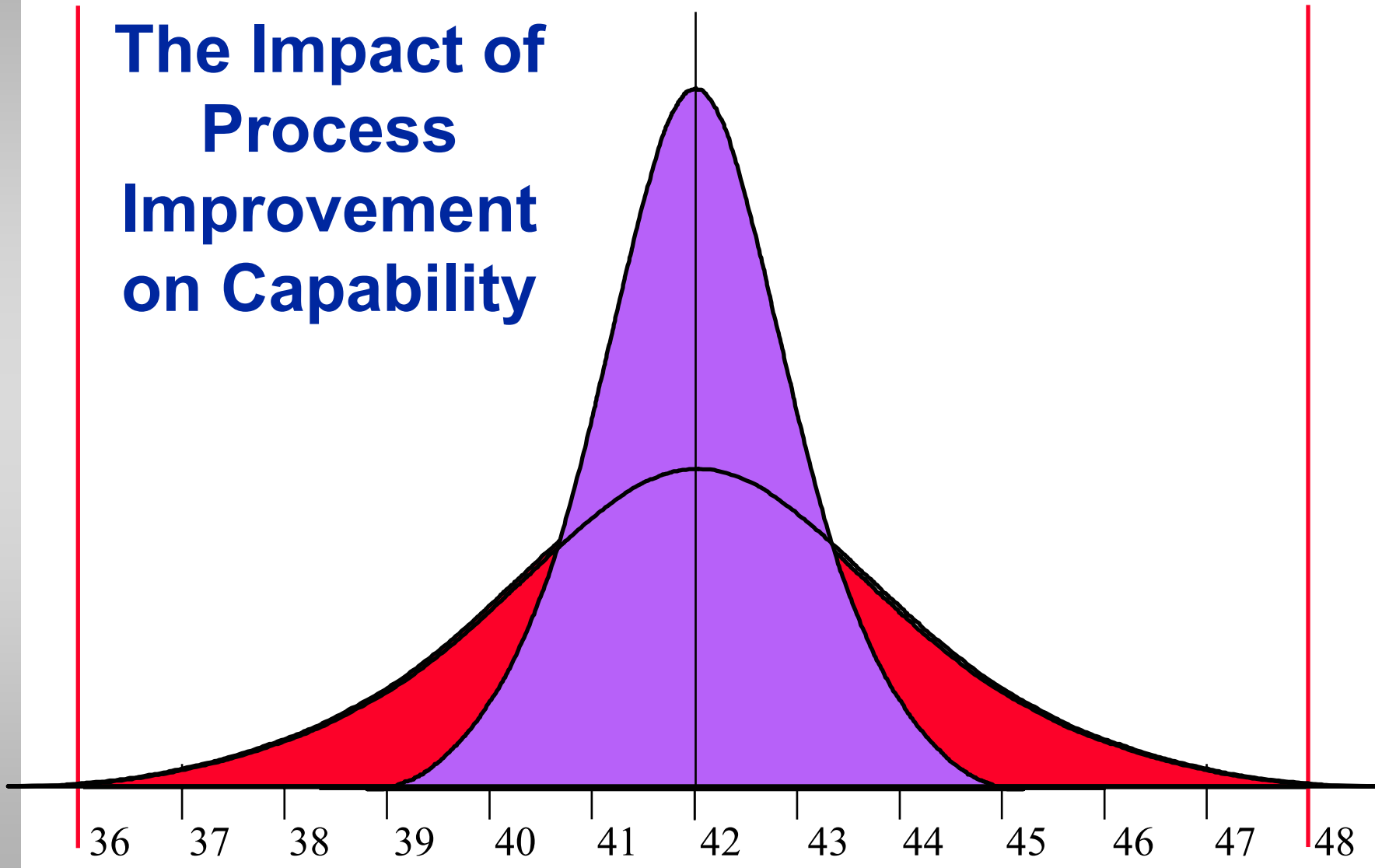
- 1. Find the distance from the grand average to the upper specification limit:

$$\frac{USL - \overline{\overline{X}}}{Sigma\ (X)}$$

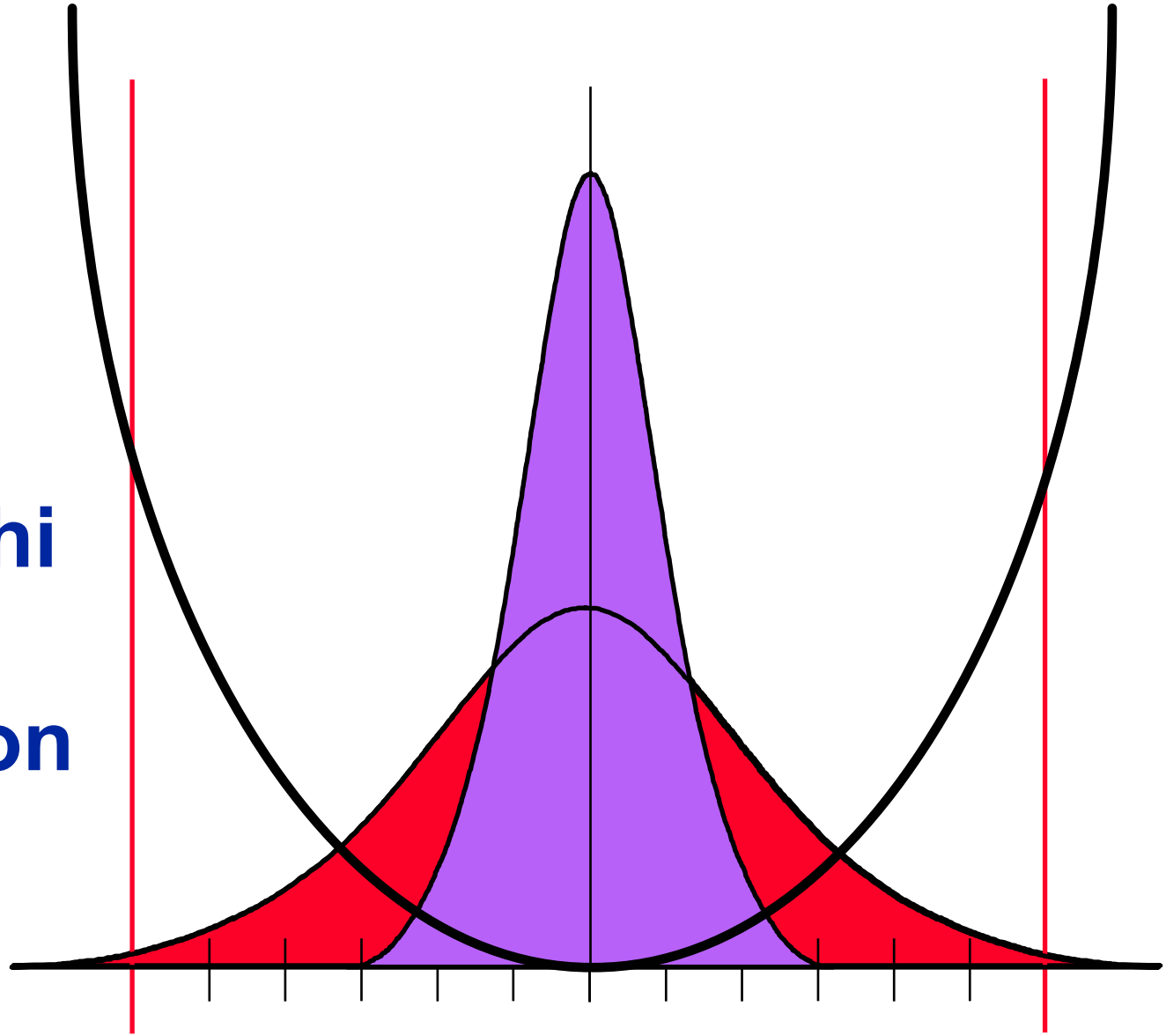
- 2. Find the distance from the grand average to the lower specification limit:

$$\frac{\overline{\overline{X}} - LSL}{Sigma\ (X)}$$

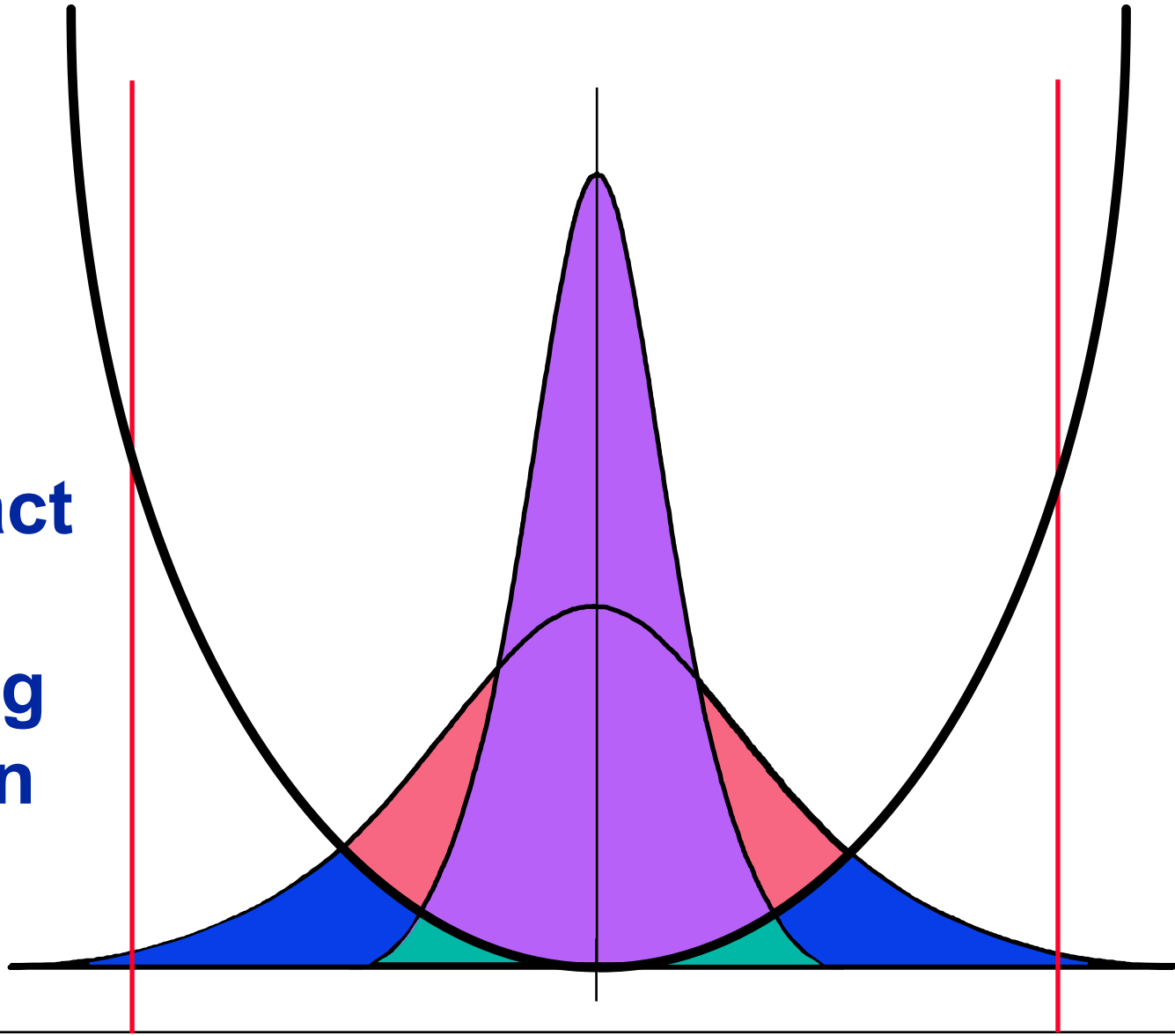
# The Impact of Process Improvement on Capability



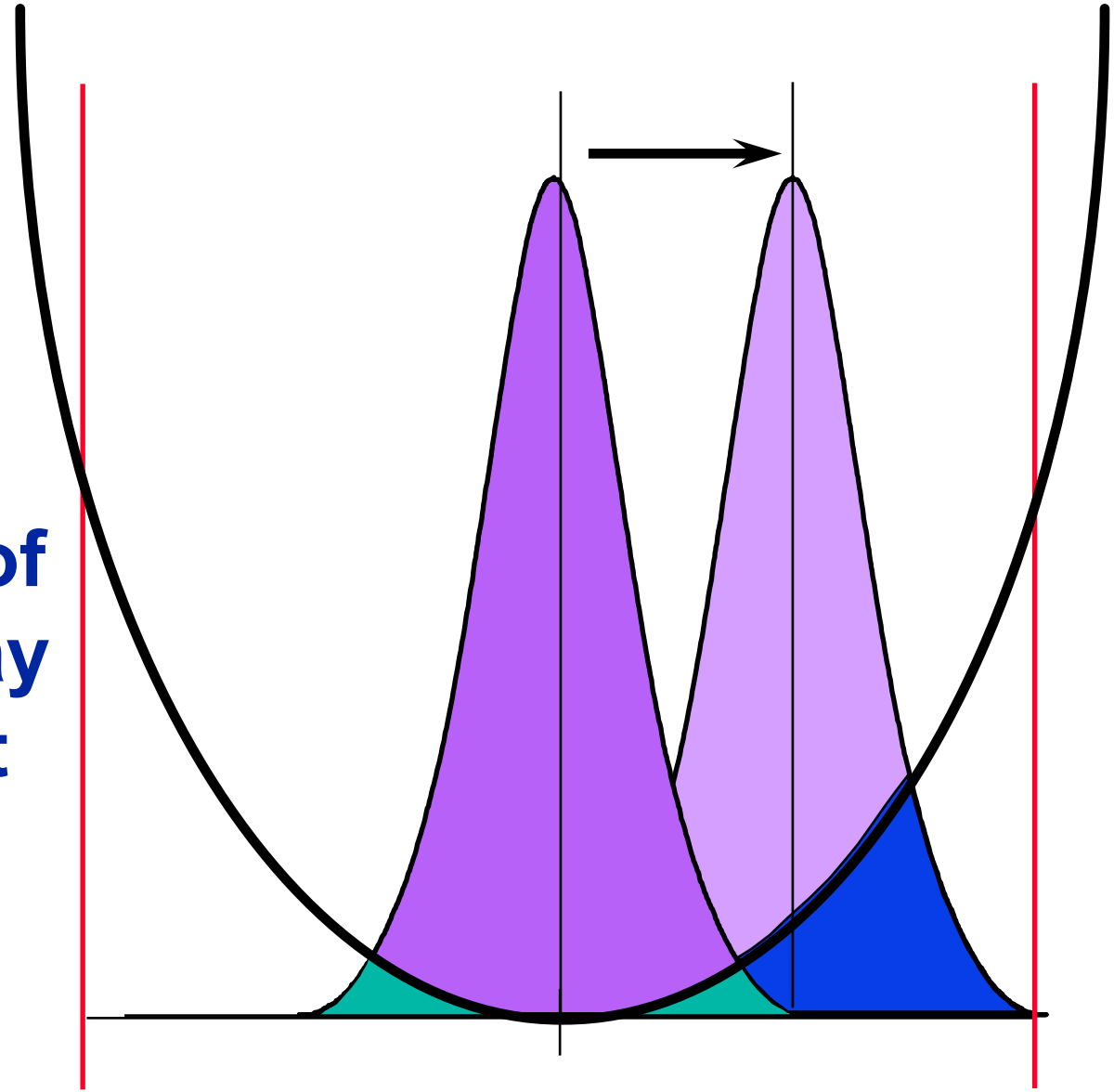
# The Taguchi Loss Function



# The Impact of Reducing Variation



# The Impact of Shifting Away from Target



# Summary

- Process capability can be interpreted only if the process is stable
- Histograms are used to depict process capability
- Other expressions of process capability
- The Taguchi Loss Function