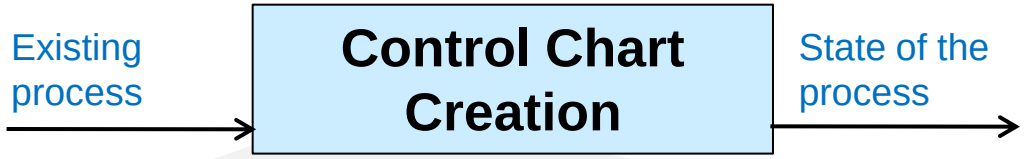
Control Chart

Problem
How to monitor defects?

Difficulty
Some training required

1. A **Control Chart** shows how a process evolves over time. It is used to monitor, control, and/or improve a process.
2. A **Control Chart** includes a
   - center line (average)

   and the data boundaries
   - Upper Control Line (UCL)
   - Lower Control Line (LCL)
3. The UCL and LCL are three standard deviations above and below the center line.
4. Process in "statistical control" if data is between UCL & LCL.



1. Determine which of 7 types of control chart to use (see example). The choice depends on
   A. data type, whether it is continuous or discrete
   B. sample size, whether or not it is constant
   C. type of analysis to be performed
2. Collect the data
3. Perform needed computations
4. Plot the results of the computation
5. Analyze the plots – look for a large variance or unusual patterns.

There are 7 control chart types

1. **Discrete data**: c, np, p, u
2. **Continuous data**:

Individual Moving Range (I-MR)
average-range (Xbar-R)
average-sigma (Xbar-S)

Constant sample size
- c: count number of defects per unit
- np: count number of nonconforming items

Proportion of nonconforming items
- p: sample size may vary
- u: large sample size variations

Control Chart – Example – Shoe Production

You are evaluating a shoe production process. Many different things could be evaluated.

What type of data to analyze?

Discrete data
(Distinct shoe defects)

What is being counted?

Total defects
(Number of bad stitches)

Constant subgroup size?

No
(number of defects per shoe)
→ **u chart**

Yes
(total number of shoe defects)
→ **c chart**

or

Proportional defective
(Percentage of stitches which are bad)

Constant subgroup size?

No
(percentage of shoes defective)
→ **p chart**

Yes
(number of defective shoes)
→ **np chart**

Continuous data
(Length of shoe)

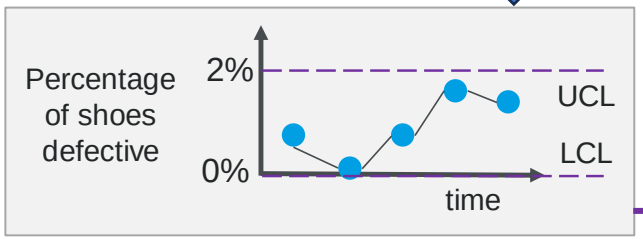
How many units are measured at once?

Individual
(Measure each shoe as it is produced)
→ **I-MR chart**

Small batch
(Measure batches of 2, 3, 4, 5, or 6 shoes)
→ **Xbar-R chart**

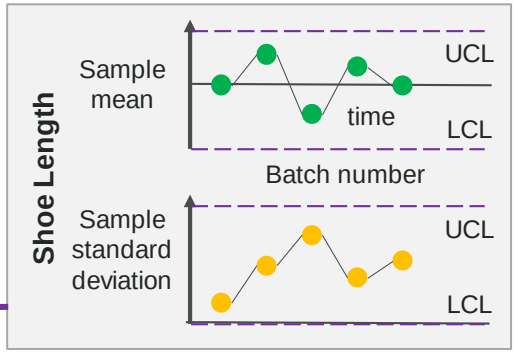
Large batch
(Measure batches of more than 6 shoes)
→ **Xbar-S chart**

Sample chart



Each chart reaches the same conclusion:
"Process is in control"

Sample chart



Control Chart – Notes

Slide 1

1. The control chart (also called a *Shewhart chart* or a *process behavior chart*) was invented by Walter A. Shewhart.
2. Control charts show the Voice of the Process (VoP); see the 6in6 on Voice of the Customer.
3. While a process in statistical control has consistent performance; it does not necessarily meet customer expectations. See the 6in6 on Statistical Process Control (SPC).
4. While analysis formulas are easy to find and use, using a statistical software package is recommended.
5. Control Chart guidelines
   A. While customers create specification limits, the UCL and LCL are computed. Specification values are *never* shown on a control chart.
   B. For an unchanging process, the UCL and LCL values are not changed.
   C. If a computed LCL value is negative, replace it with the value zero.
   D. Ensure that enough data is collected to make decisions; software packages will indicate when not enough data has been obtained.

Slide 2

1. This example shows what the 7 different types of control charts represent.
2. The example is for shoe production and indicates the different types of defects that might be interest:
   A. variation in a continuous value (such as shoe length), or
   B. variation in a discrete value (such as number of bad stiches per shoe, or the number of defective shoes).
3. For discrete data, a single chart is created. For continuous data, two charts are created (one for the mean of the process and one for the standard deviation of the process).

Recommended web sites for additional information

- https://bootcamp.umass.edu/blog/quality-management/ultimate-guide-to-six-sigma-control-charts
- https://sixsigmastudyguide.com/control-charts-study-guide/