Continuous Improvement Toolkit

Control Charts


Managing Risk
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RAID Logs
Fault Tree Analysis
Risk Assessment*
Traffic Light Assessment
Deciding & Selecting
Pros and Cons
Importance-Urgency Mapping
Break-even Analysis
Cost -Benefit Analysis
Force Field Analysis
Voting
Pugh Matrix
Decision Tree
TPN Analysis
QFD
Matrix Diagram
Kano Analysis
Prioritization Matrix
Critical-to Tree
Paired Comparison
Planning & Project Management*
RACI Matrix
Stakeholders Analysis
PEST
PERT/CPM
Activity Diagram
SWOT
Roadmaps
Project Charter
Gantt Chart
PDCA
Control Planning
Gap Analysis
Hoshin Kanri
Kaizen
How-How Diagram
Tree Diagram**
Standard work
Lean Measures
KPIs
OEE
Capability Indices
MSA
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Descriptive Statistics
Cost of Quality
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Graphical Analysis
Cause & Effect Matrix
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Understanding Cause & Effect
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Multi-Vari Charts
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Identifying & Implementing Solutions***
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Creating Ideas**
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IDEF0
Value Stream Mapping
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Flow Process Chart
Process Mapping
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Focus groups
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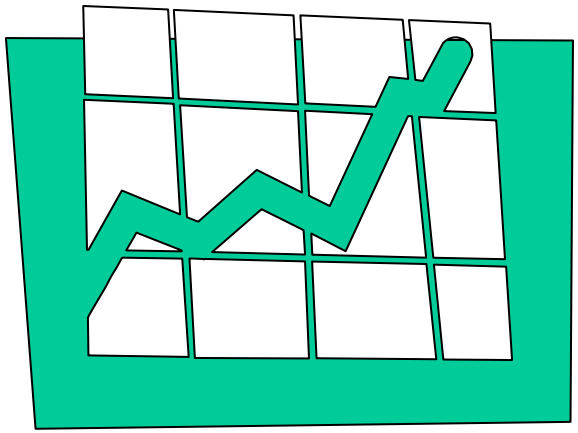
Photography
Check Sheets
Measles Charts
Surveys
Data Collection
Critical Incident Technique
Observations

- Control Charts

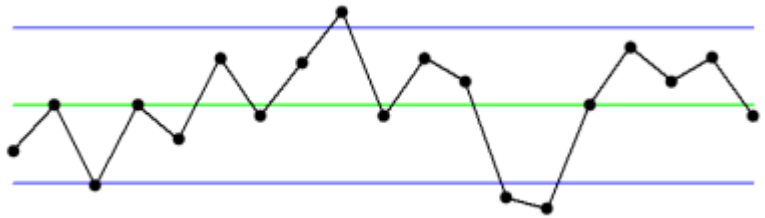
- A control chart is a plot of data overtime.
- It is a line graph of data points plotted in chronological order.
- These data points represent measurements, counts, or percentages of process output.
- It helps analyze the current level of process stability.
- Processes that are out of control need to be stabilized before they can be improved.



- Control Charts

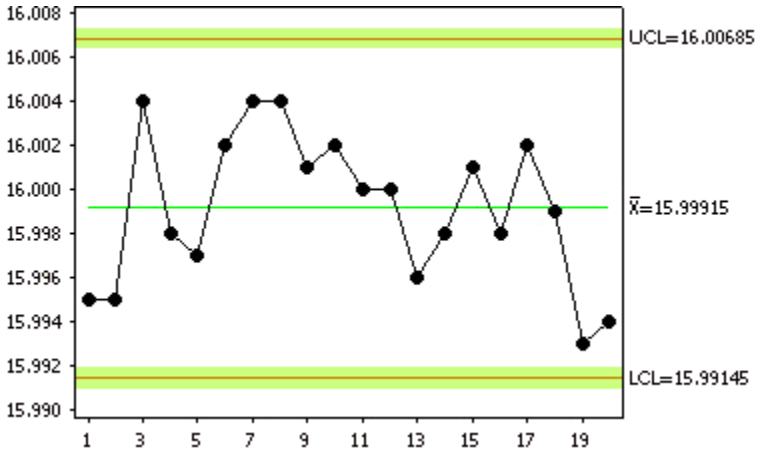
When to Use It?

- Analyze data for patterns and trends that are not easily seen in tables or spreadsheets.
- Understand variation in process performance so we can improve it.
- Monitor process performance over time and signal when it goes out of control.
- Communicate how a process is performed during a specific time period.



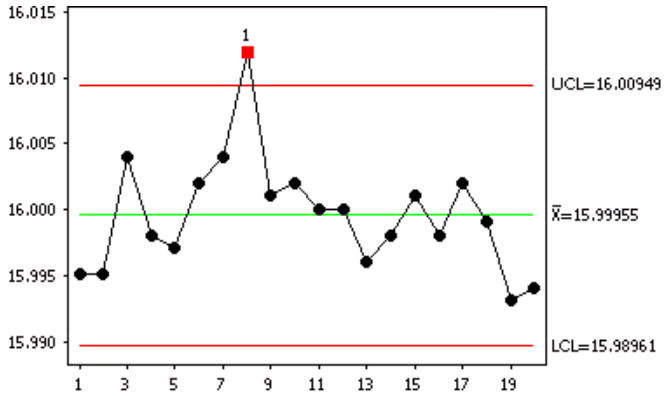
- Control Charts

- A control chart plots the result of a process over time against three reference lines:
  - A center line (a nominal value).
  - An upper control limit.
  - A lower control limit.
- These lines are calculated from the data.
- They reflect the central tendency and spread of the measured data.



- Control Charts

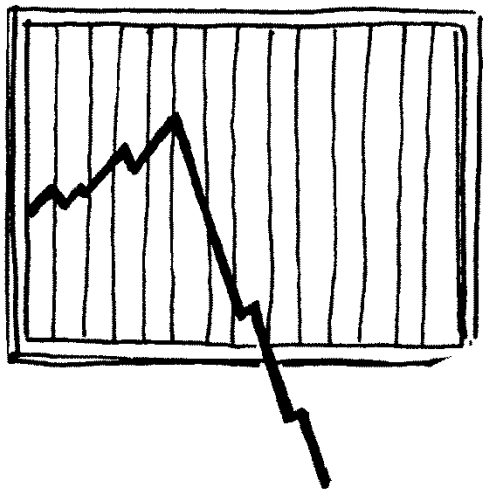
- A process is **in control** when all points:
  - Are within the control limits.
  - Have no obvious patterns or trends.
- When all points fall between the limits, the process is exhibiting **common causes of variation**.



- When at least one point falls outside the control limits, the process is exhibiting **assignable causes of variation**.
- Special cause of variation is caused by something unusual in the process.

- Control Charts

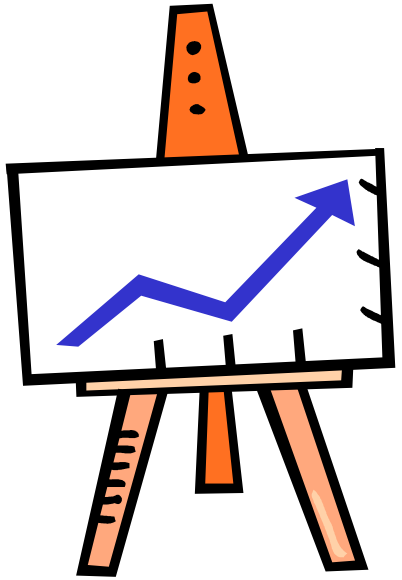
- If the process is **out of control**:
  - Look for unusual sources of variation (assignable causes).
  - Try to eliminate the cause if it degrades performance.
  - Try to incorporate the cause if it improves performance.
  - Reconstruct the control chart with new data.
  - Repeat this procedure periodically.



- Control Charts

Out of Control:

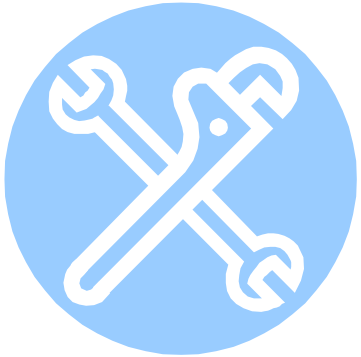
- Sometimes problems with a process can be detected even though the control limits have not bee exceeded.
- An example of a **shift** is when you see a number of consecutive points on one side of the center line.
- An example of a **trend** is when you see a number of consecutive points in the same direction (up or down).
- An example of a **pattern** is when you see a pattern that recurs a number of times in a row.



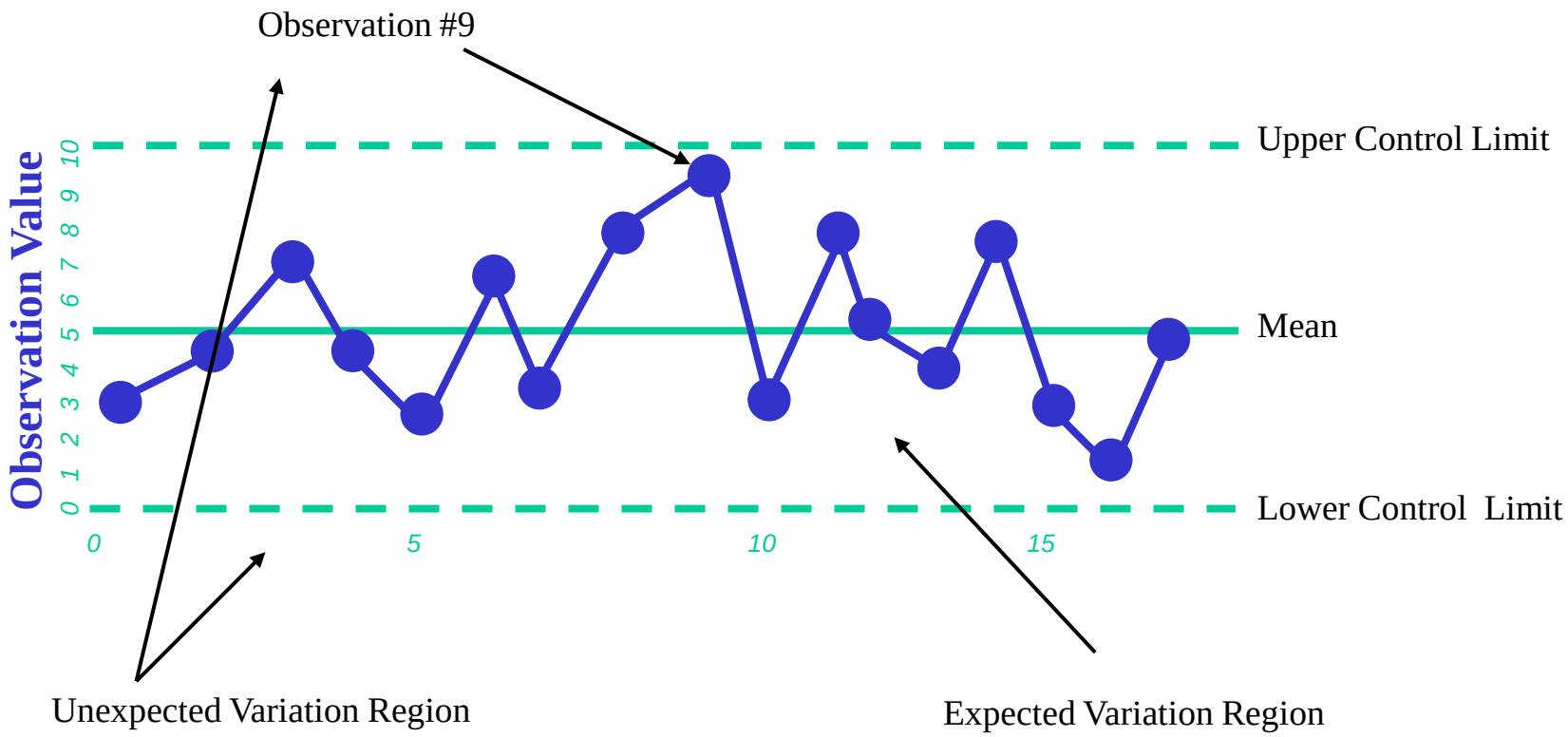
- Control Charts

Approach:

- Determine how to collect data, sample size, and frequency of sampling.
- Collect and record the data (At least 25 samples should be collected).
- Calculate appropriate statistics.
- Draw the chart stating the center line and the control limits.
- Plot the data on the chart.
- Analyze the results and determine if in-control or not.



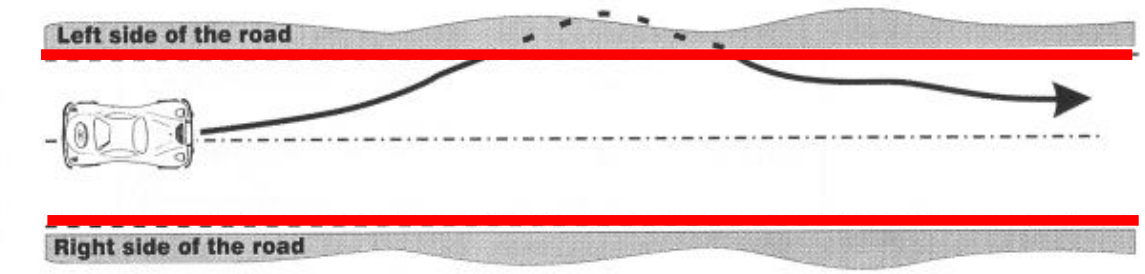
- Control Charts

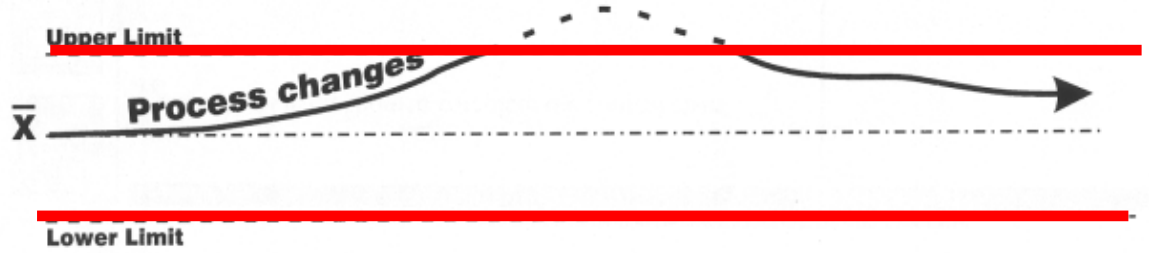


- Control Charts

- Typically, the upper and lower control limits are **3 sigma** level above and below the center line.
- 3 sigma limits provide bounds that can indicate the presence of unusual sources of variation in the process.

- Control Charts

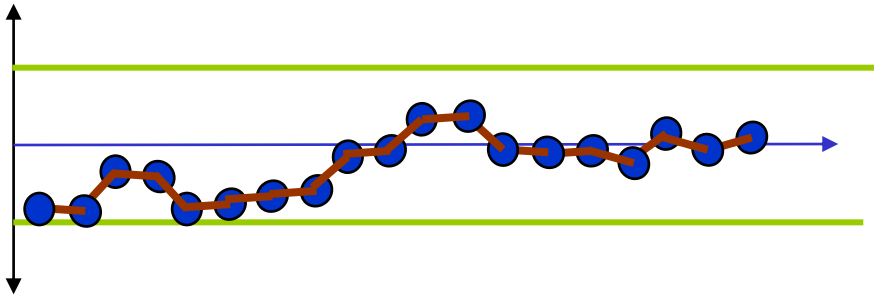




- Control Charts

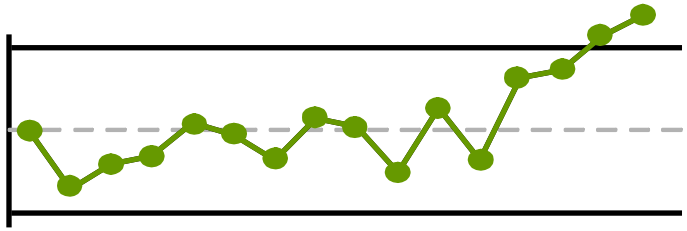
Things to Look Out For:

- Points that fall outside the control limits.
- Upwards or downwards trends.
- Changes in the amount of variation.
- Differences between the short and the long term.
- Sudden shift in process mean.
- Patterns or cycles in the data.
- Anything that doesn't appear to be random.

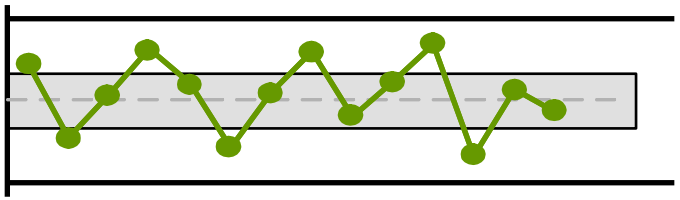


- Control Charts

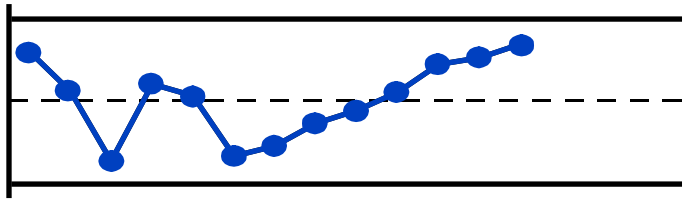
Typical Out of Control Examples:



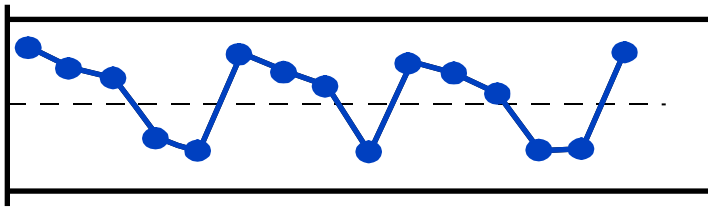
Outside control limit



Large Spread



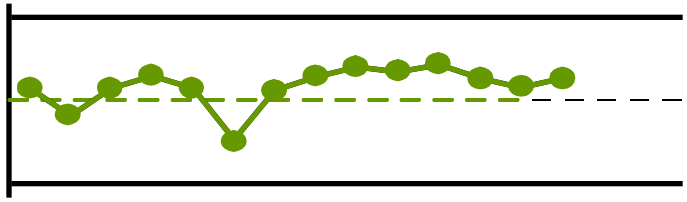
Increasing trend or continuous movement



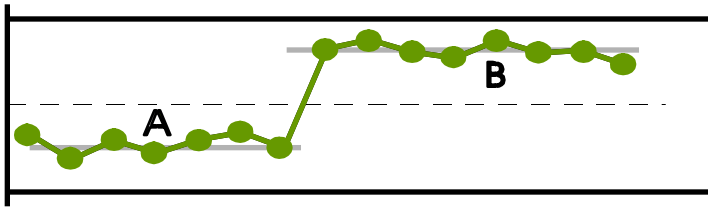
Cyclical pattern

- Control Charts

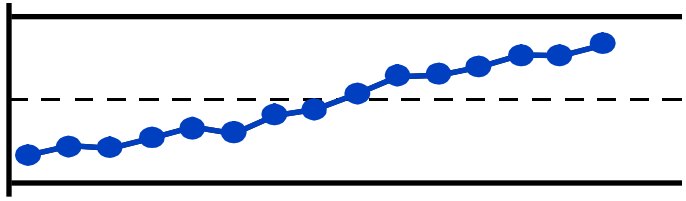
Typical Out of Control Examples:



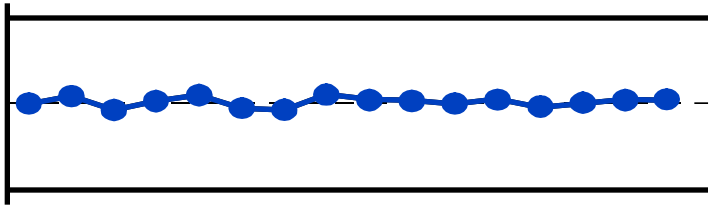
Shift in process average



A sudden change in centrality



Gradual going out of control

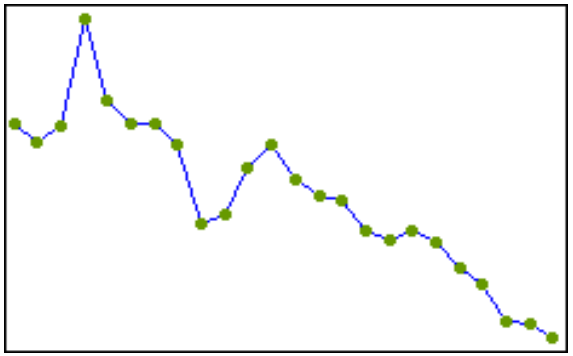


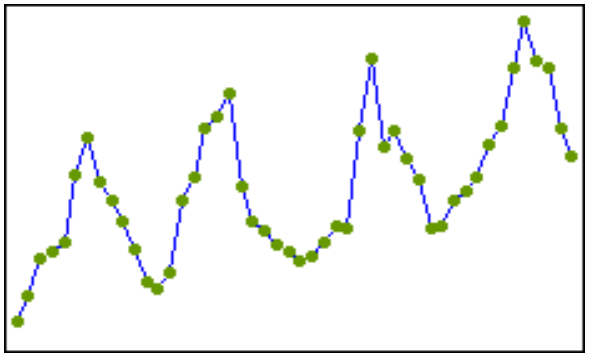
Measurement error

- Control Charts

Typical Out of Control Examples:

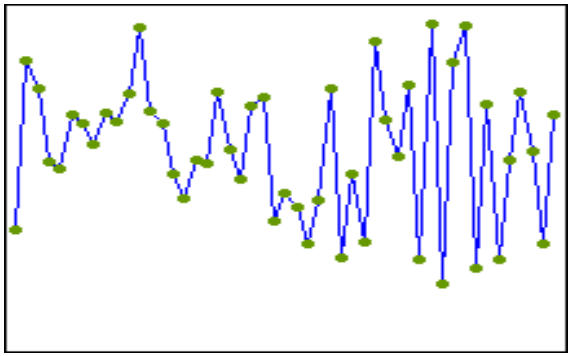
Downward trend

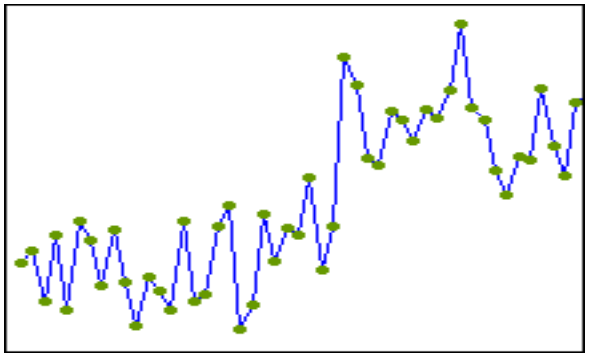




Cycle or Seasonal fluctuation

Fluctuation more at the end

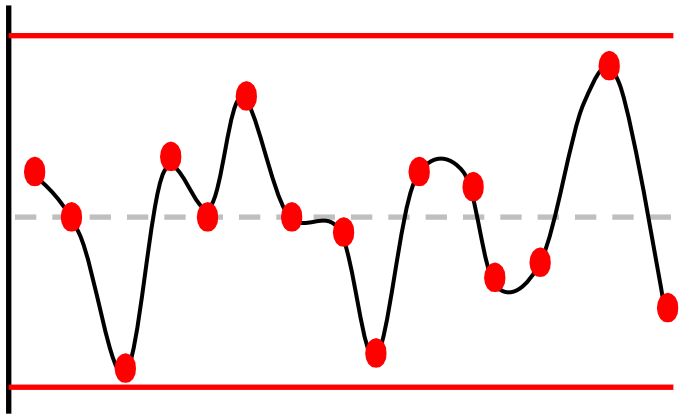




Change in the process or change in the method of data collection

- Control Charts

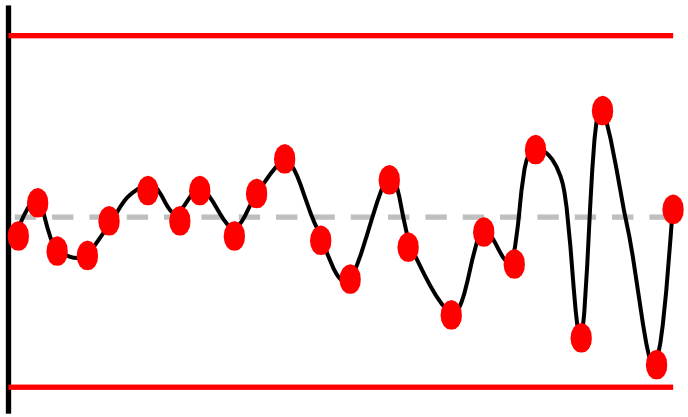
- **Question:** Do the points appear to be randomly distributed and independent?



- **Answer:** Yes, there are no unusual pattern indicating that data observations are random and independent.

- Control Charts

- **Question:** Do the points appear to be randomly distributed and independent?



- **Answer:** No, there is unusual pattern which is increase in the variation over time.

- Control Charts

Control Charts Types:

- I-MR Charts
- X-bar Charts
- R Charts
- S Charts

Variable Data

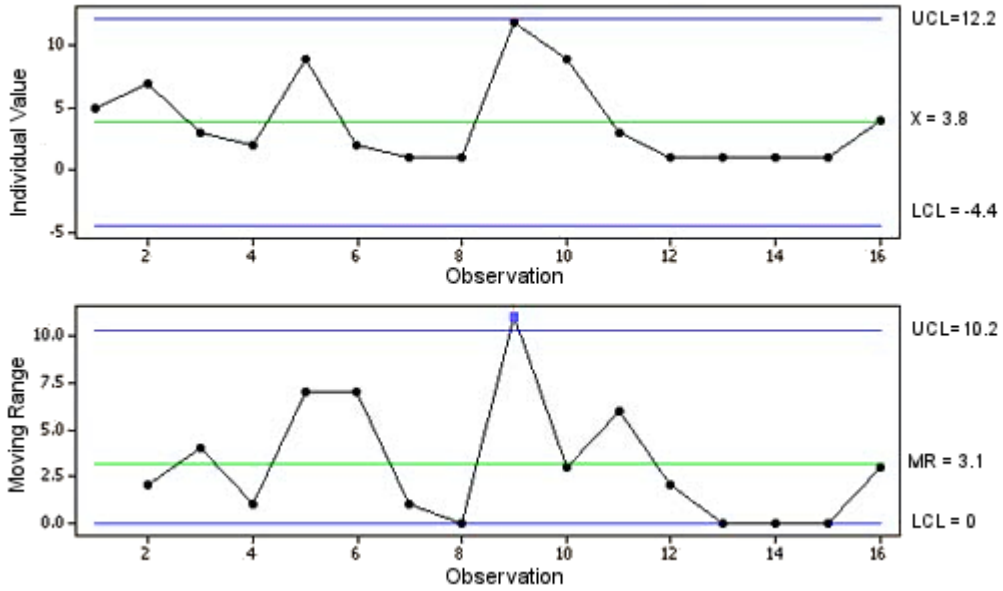
- NP Charts
- P Charts
- U Charts
- C Charts

Attribute Data

- Control Charts

I-MR Charts (Individual Moving Range Charts):

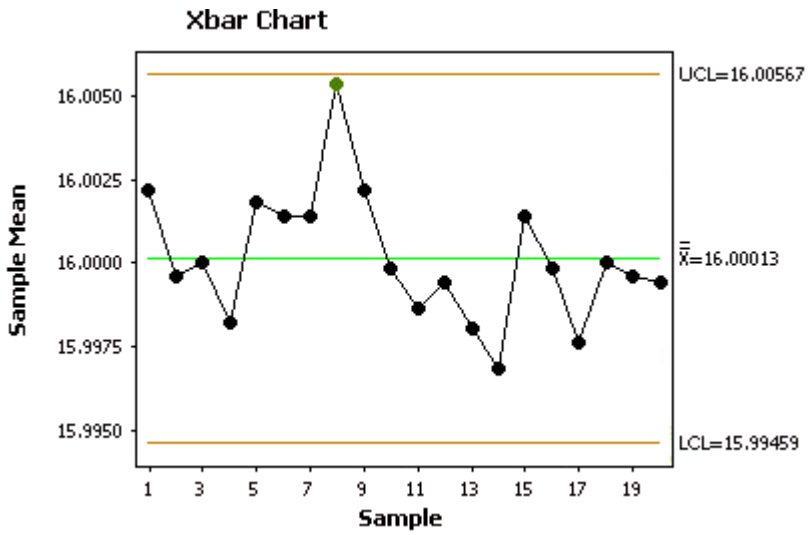
- Plots individual data and the moving range of the present and previous individuals.
- Used to monitor process variation when data are collected as individual measurements (with subgroups of size one).



- Control Charts

X-bar Charts:

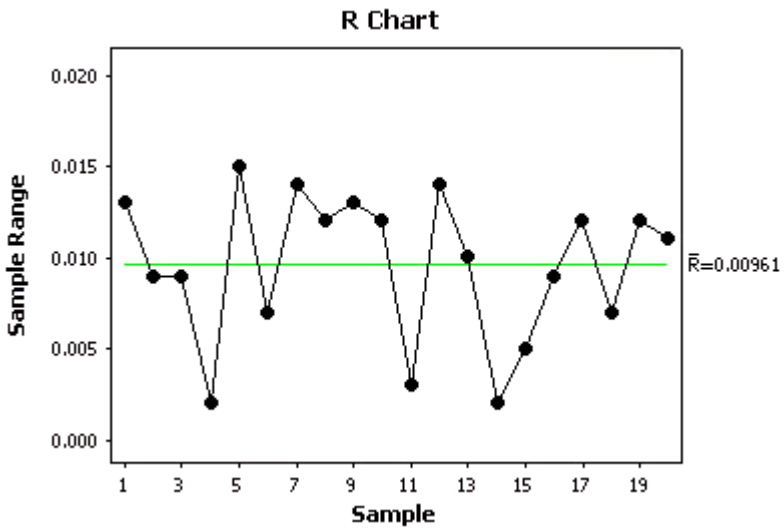
- The X-bar chart plots subgroup means over time.
- The upper and lower control limits on an X-bar chart are based on within-subgroup variation and subgroup size.



- Control Charts

R Charts:

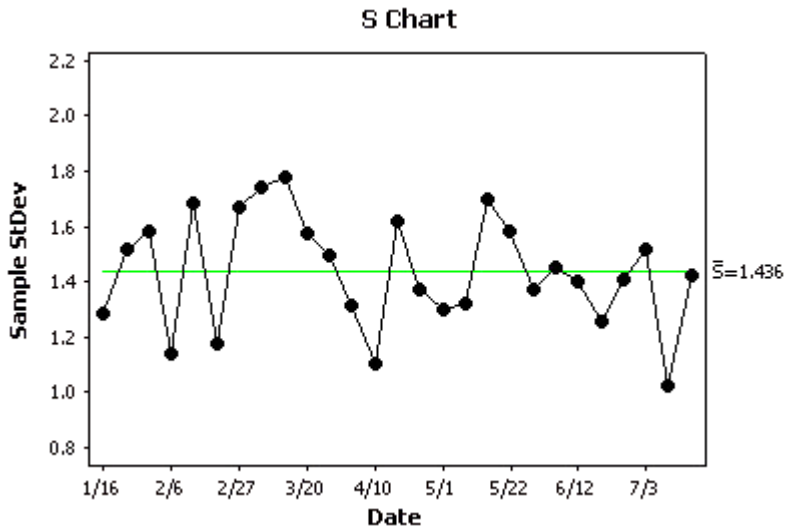
- The R chart plots sample ranges for each subgroup over time.
- Evaluates whether within-subgroup variation is stable over time.
- Used when subgroup sizes are small (generally eight or less).



- Control Charts

S Charts:

- The S chart plots sample standard deviations for each subgroup over time.
- Evaluate whether within-subgroup variation is stable over time.
- Used when subgroup size are large (generally greater than eight).



- Control Charts

Defects vs. Defective:

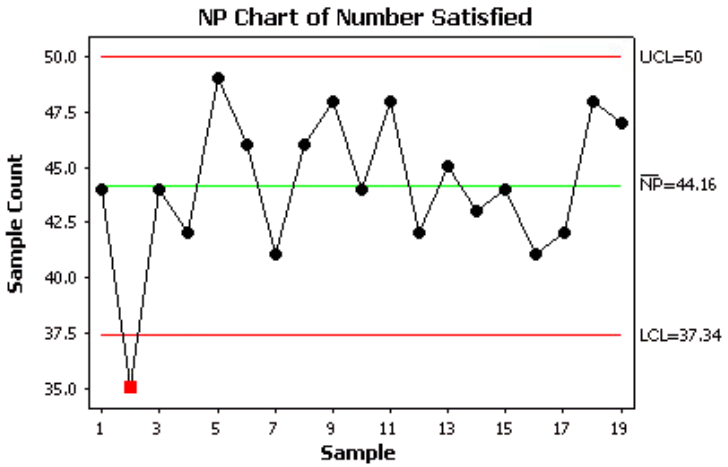
- **Defects:**
  - Faults / non-conformities which cause an item to fail to meet the required standard.
  - There can be more than one defect per item.

- **Defective:**
  - Items which fail to meet the required standard due to the presence of defects.
  - The item is either defective or not.

- Control Charts

NP Charts:

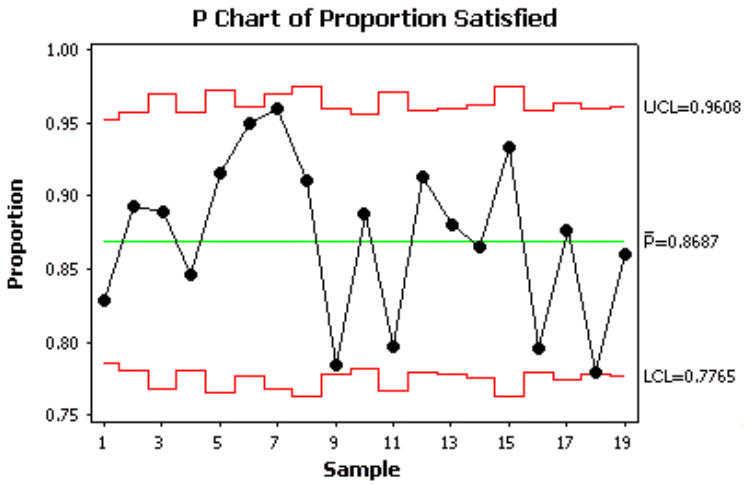
- Used to monitor the number of defectives or non-conforming units in a sample.
- NP charts are used when subgroup sizes are the same across the samples.
- Used for processes where the measurement system is only capable of determining whether a unit is defective of not.



- Control Charts

P Charts:

- Used to monitor the number of defectives or non-conforming units in a sample.
- P charts are used when subgroup sizes are different across samples.



- Control limits are dynamic and depend on the size of the sample.
- Often used when samples are form natural grouping.
- For example the number of treatments in a hospital in a week.

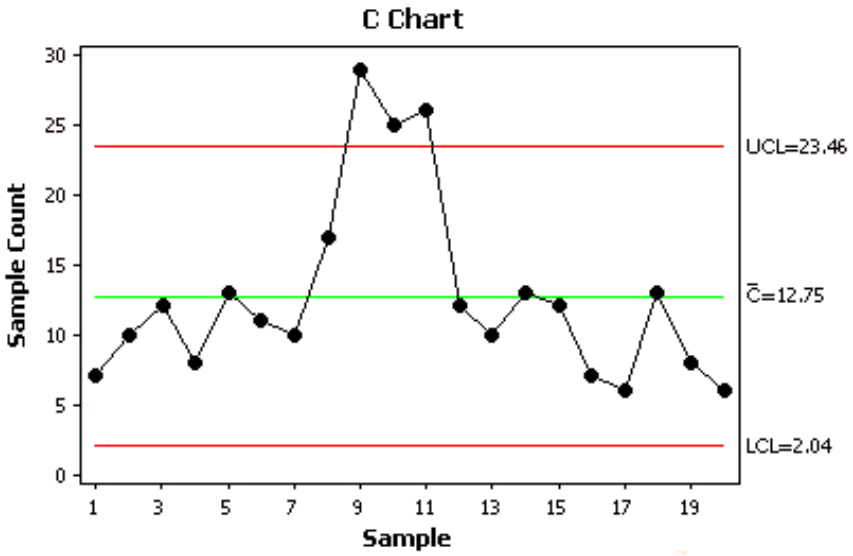
- Control Charts

C Charts:

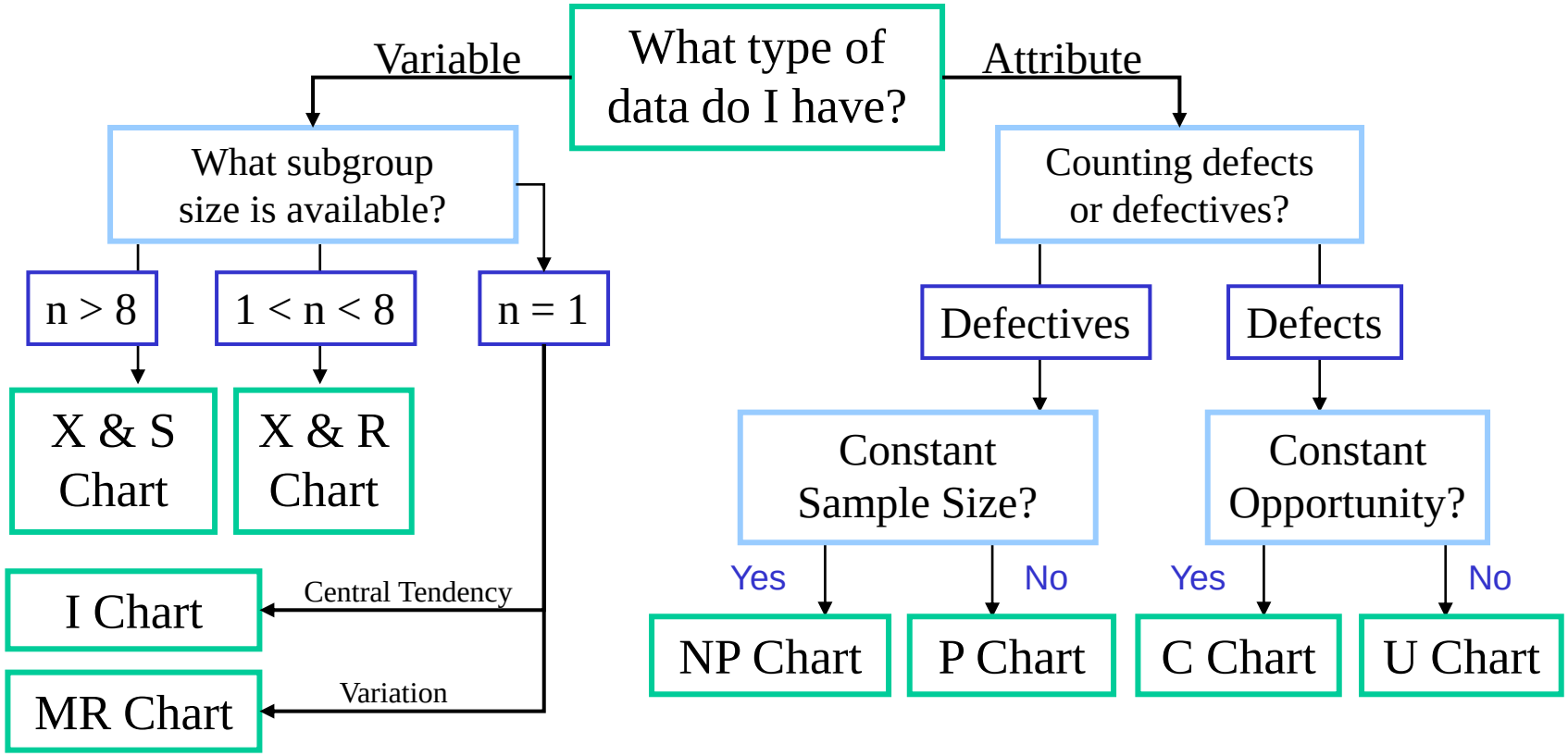
- Used to monitor the total number of defects in a sample over time.
- Used when subgroup sizes are the same across samples.

U Charts:

- Used to monitor the total number of defects in a sample over time.
- Used when subgroup sizes are different across samples.



- Control Charts



- Control Charts

Further Information:

- To monitor the ongoing process performance, we use:
  - Process control charts.
  - Process capability study.
- Control charts must be constructed after the process variability is in control.
- Control charts are not perfect tools for detecting shifts in the process distribution as they are based on sampling distributions.
- If no assignable causes are found after a thorough search, assume that the out-of-control points represent common causes of variation and continue to monitor the process.