FLORIDA POLYTECHNIC UNIVERSITY

# Six Sigma – Week 14

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Fall 2020

# Agenda

- ✓ Week 12
  - ✓ (11/5): Multiple linear regression – work on homework in class
  - ✓ (11/7): Binary logistic regression; start process capability
- ✓ Week 13
  - ✓ (11/12): Work on Case Study 2
  - ✓ (11/14): Process capability
- Week 14
  - (11/19): Process capability and control charts
  - (11/21): Work on final team projects
- Week 15
  - (11/26): Final team project presentations
  - (11/28): No class – Happy Thanksgiving
- Week 16
  - (12/3): Topic review (last day of class)
- Final Exam Week
  - (12/10): Final exam – 6:30pm-8:30pm – IST 1065

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# Control Charts

- Video: What is a Control Chart?
  - https://www.youtube.com/watch?v=uPTdz8mkxi8
- Control Charts
  - I-MR Chart (Individual – Moving Range)
  - X Bar-R Control Chart
  - U Chart
  - P chart

# LS Text: Control Charts

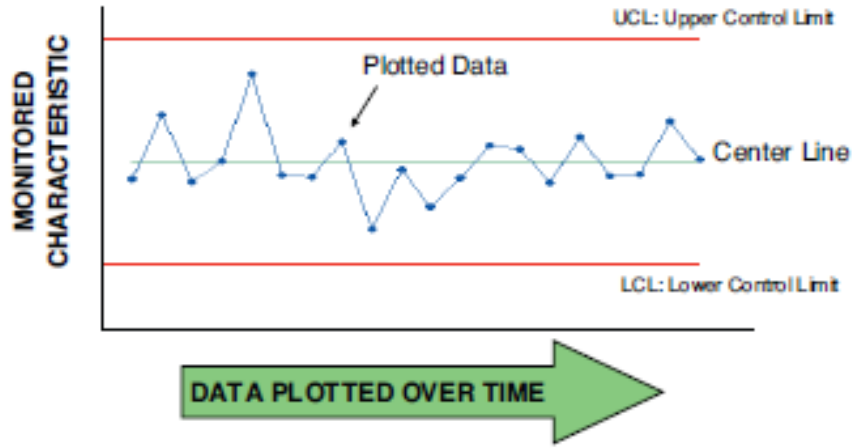



**Figure 8.11.1** Structure of a Control Chart

Control limits (UCL & LCL) are +/- 3 Sigma (3 standard deviations) away from mean

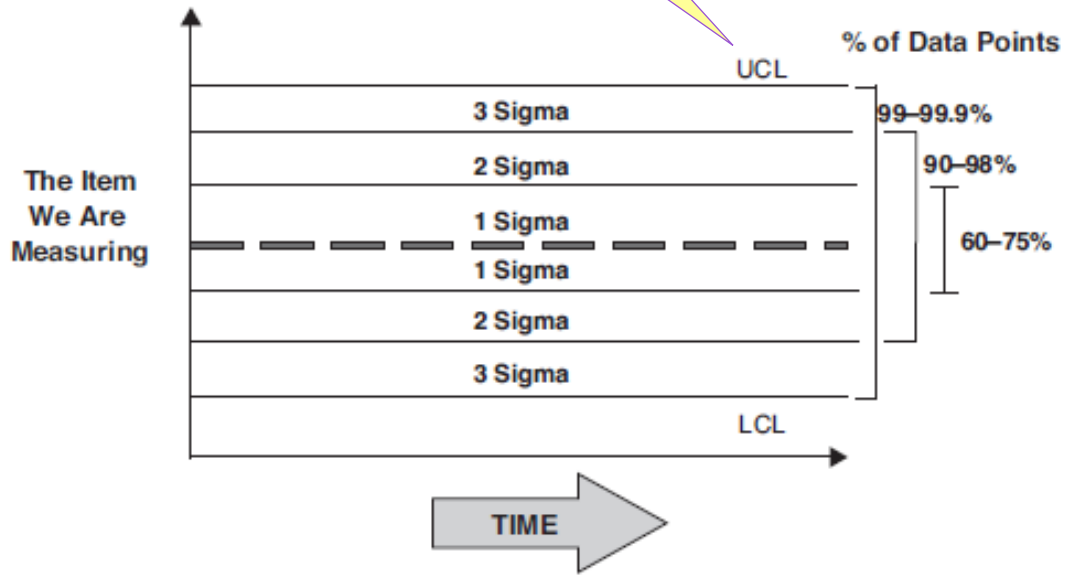



**Figure 8.11.2** Distribution of data points with respect to standard deviations in a normal distribution

*Do not confuse control limits with specification limits.*

- Control limits are calculated based on the data from the process itself.
- Specification limits do not appear on a control chart; they are specified by the customer or required design.

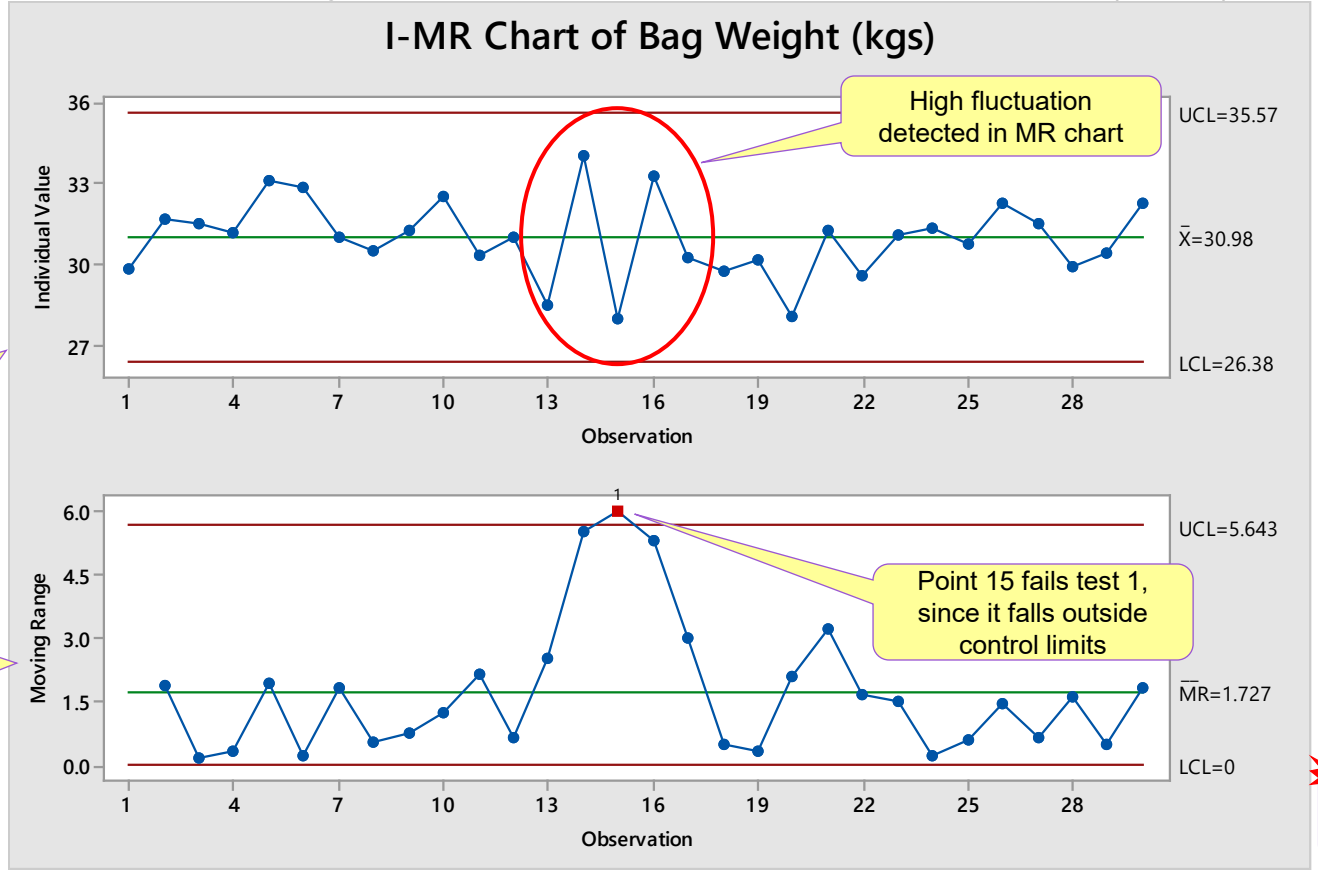
# LSSM Text: Control Charts - Individual-Moving Range (I-MR)

***Example:*** A building materials company is investigating the amount of sand its filling process puts into each bag. Data file contains historical data of 30 bags to help us understand if process is in control (stable).

***I-MR Chart***
For use with continuous data that does not have any rational subgroups. All data points have been collected individually. ***Data should follow normal distribution.***

Individuals Chart
Shows time series plot of data with control limits. Control limits set at +/- 3 Sigma (3 standard deviations) away from mean

Moving Range Chart
Data point 3 on MR chart is the range (difference) between data points 2 and 3 on Individuals Chart, etc.




Although average is stable, there is indication that the variation is not stable.

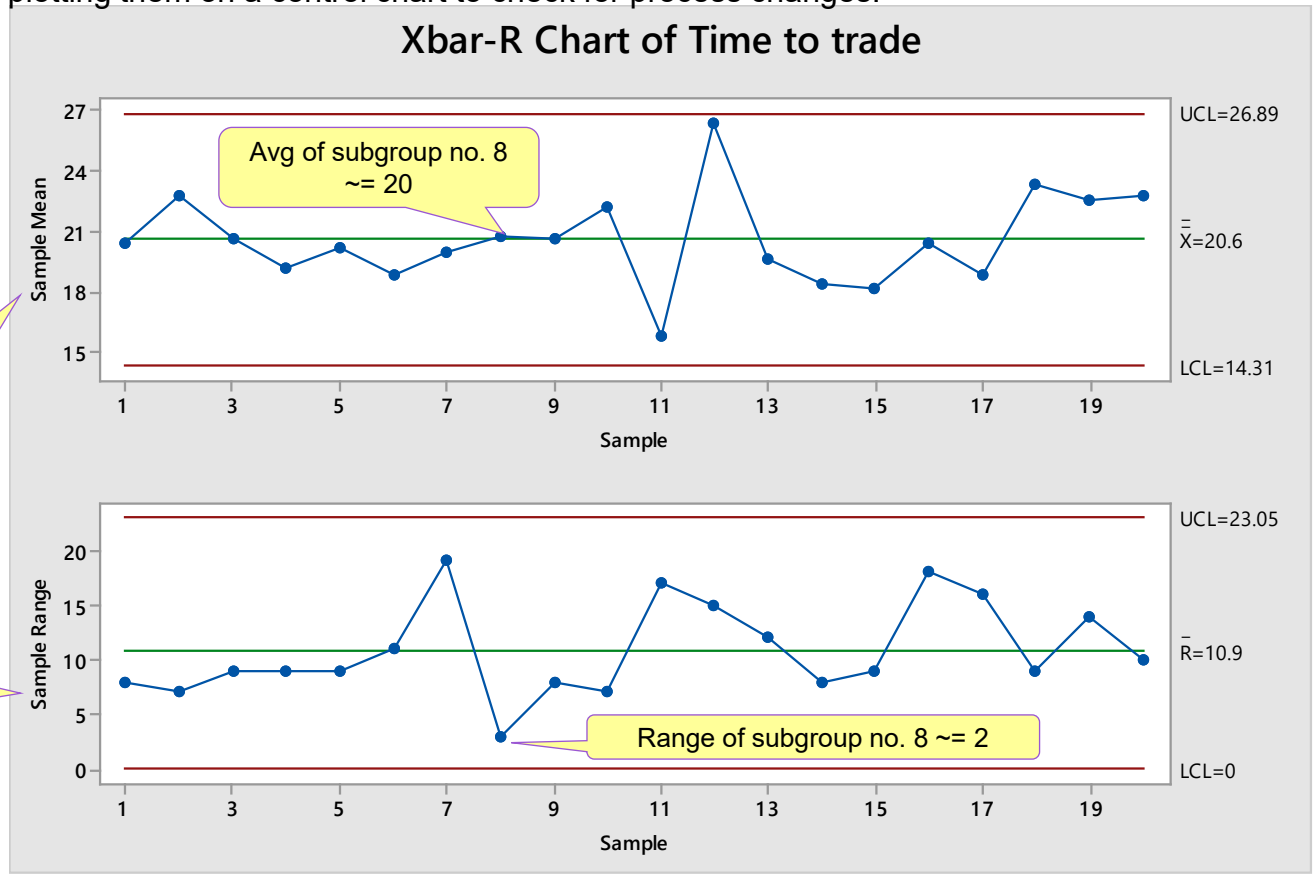
# LSSM Text: Control Charts – X Bar-R (Average Range)

***Example:*** A share trading company has completed a project that has reduced the average time required for its share/stock instructions to be traded, down to an average of 20.6 minutes. They are now monitoring the new, improved process by randomly selecting five consecutive trades each day and plotting them on a control chart to check for process changes.

***X Bar-R Chart***
Used with small subgroups of continuous data. ***Raw data does not have to be normally distributed (as it plots averages, not individual data points).***

X Bar Chart
Shows time series plot of averages of subgroups with control limits. Control limits reflect variation in subgroup averages

Range (R) Chart
Shows range of data within each subgroup.



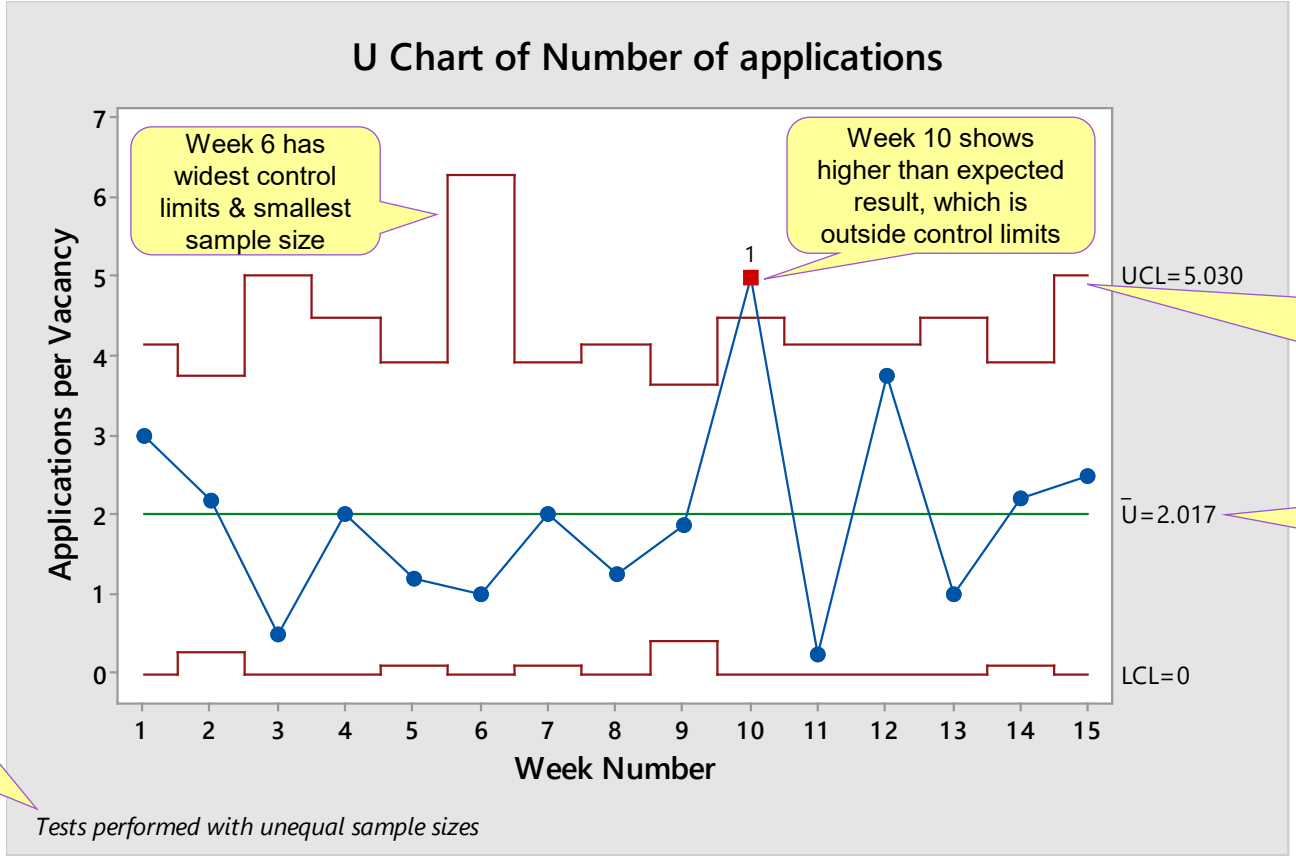

X Bar-R chart is useful choice when we have small subgroups of continuous data being collected over a longer time period.

No statistical tests have been failed on either chart. Both average and variation of process are stable (in control).

# LSSM Text: Control Charts: U Chart

***Example:*** A human resources department is looking at the number of internal applications they receive for each vacancy that they advertise. They have 15 weeks of data available for analysis to understand if number of internal applications per vacancy is stable (in control) or changing over time.

***U Chart***
Useful for count data, such as counting defects, counting phone calls, or counting hospital operations.




*Tests performed with unequal sample sizes*

Due to subgroup size (the number of vacancies posted each week) varies, the control limits adjust from week to week to reflect different subgroup sizes.

Overall average DPU – avg. no. of internal applications per vacancy advertised, over 15 weeks = 2

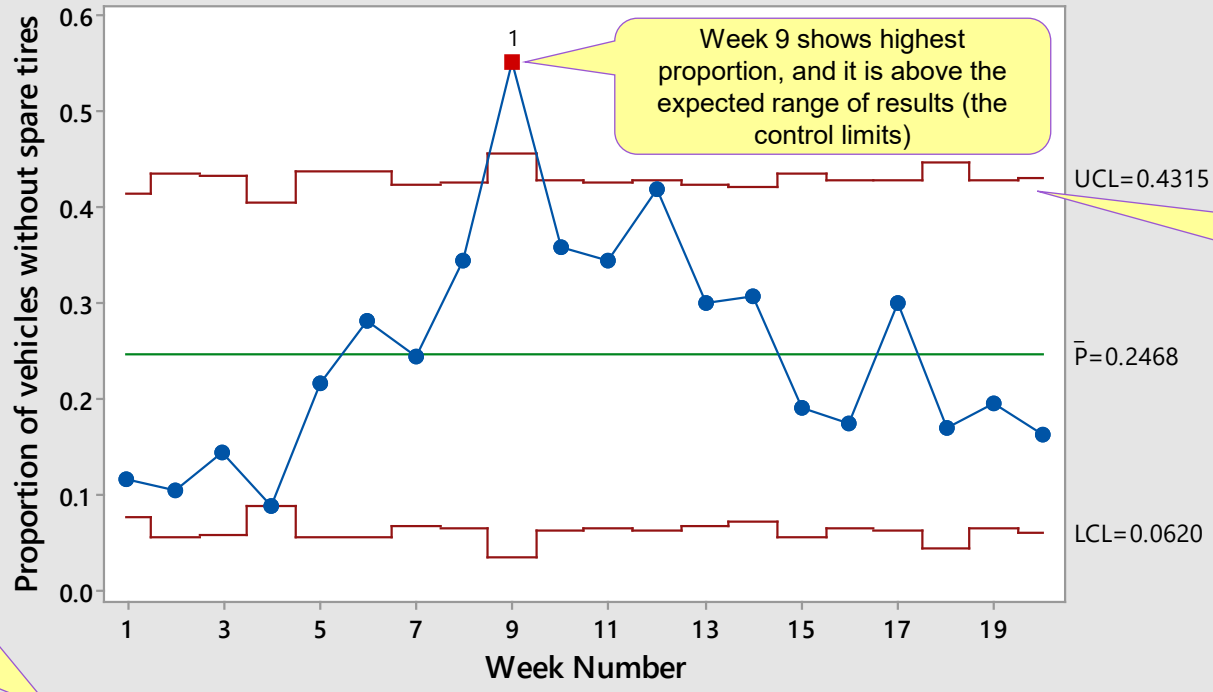
This chart shows no clear rise or fall in the results. But week 10 shows an unexpectedly high result (outside of control limits), which should be investigated further.

Subgroup size does not need to be constant. U chart can accommodate this because it analyzes the number of applications per vacancy (post).

# LSSM Text: Control Charts: P Chart

***Example:*** A car breakdown service has noticed an increase in the proportion of vehicles that do not have a functional spare tire over the summer months. The team has 20 weeks of historical data from spring to autumn for analysis. Each week a random selection of drivers were asked if they had a functional spare tire in their car, and results were recorded over a 20 week period..

***P Chart:***
Useful with attribute data (usually summarized as proportions or percentages)




Week 9 shows highest proportion, and it is above the expected range of results (the control limits)

Due to subgroup size (the number of drivers questioned) varies, the control limits adjust from week to week to reflect different subgroup sizes.

Subgroup size does not need to be constant. P chart can accommodate this because it analyzes the proportion of cars without a spare tire.

*Tests performed with unequal sample sizes*

This chart shows a clear rise and fall in the results which supports team's original hypothesis – that there is an increase in proportion of vehicles without functional spare tires during summer months. This is supported (statistically) with data point for week 9 being outside of control limits.

# Control Plan Summary

- For each process step, a control plan defines the characteristics that are measured, their specification, historical capability, measurement method used, and a response plan if out of specification (Text 2 page 259)
  - Summarize many of the tools used in project (process mapping, process measures, VOC, process capability, etc.)
- Control Plan Summary Template – Text 1 page 237
  - summarizes a more detailed Control Plan

**Control Plan Summary**

**<Process X>**

| **Purpose** | **Response Owner/Decision Maker** | **Control Element/Decision Mechanism** | **Metric/Measure** (What) | **Frequency/When** (How often and at what point) | **How does it happen** (including sample size, etc.) | **Level of Performance** • **Goal** • **Trigger Point** | **Appropriate Reaction/Response** (by criteria) |
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Champion: _____ Process Owner: _____

Rev.: _____