Statistical Process Control (SPC) Overview

SixSigmaTV.Net

SPC - Agenda

Statistical Process Control History

Review fundamentals of Control Charts

Understand the impact of variation within your process

Construct and interpret Control Charts to monitor process performance

Control Charts: A Brief History

- Dr. Shewhart of Bell Laboratories introduced Control Charts in 1924. He developed a theory of variation that states there are two components to variation:
  1. Common cause - the collection of conditions inherent in any process
  2. Special cause - identifiable causes or conditions directly responsible for process shifts
- Dr. Shewhart is credited with the development of the standard control chart based on 3 standard deviation limits to separate common cause variation from special cause variation.
- Control Charts became widely used by the US Military during World War II.
- Dr. Deming introduced Control Charts to the Japanese in the 1950s. They consider this their turning point to re-building Japan after the war and making them a formidable leader in the industrial world.

Control Charting

- What is it?
  - A technique for applying statistical analysis to measure, monitor and control processes
- When do I apply it to my process?
  - To establish a baseline of performance.
  - To determine if a process is stable and predictable.
  - To determine if a shift has taken place.
  - To avoid tampering.
  - To identify impacts of process variation.
  - To monitor and control critical Xs, Ys & implemented solutions.

Control Charting

- What is it?
  - A technique for applying statistical analysis to measure, monitor and control processes
- When do I apply it to my process?
  - To establish a baseline of performance.
  - To determine if a process is stable and predictable.
  - To determine if a shift has taken place.
  - To avoid tampering.
  - To identify impacts of process variation.
  - To monitor and control critical Xs, Ys & implemented solutions.

Control Charts - Purpose

- Provide feedback on process performance
  - Shows the natural variation of the process
  - Provides process monitoring / feedback
  - Measures the health of the process
- Identify when process performance changes
  - Due to deterioration and neglect
  - Due to the introduction of outside influences ("special" causes)
- Allows timely action for process adjustments

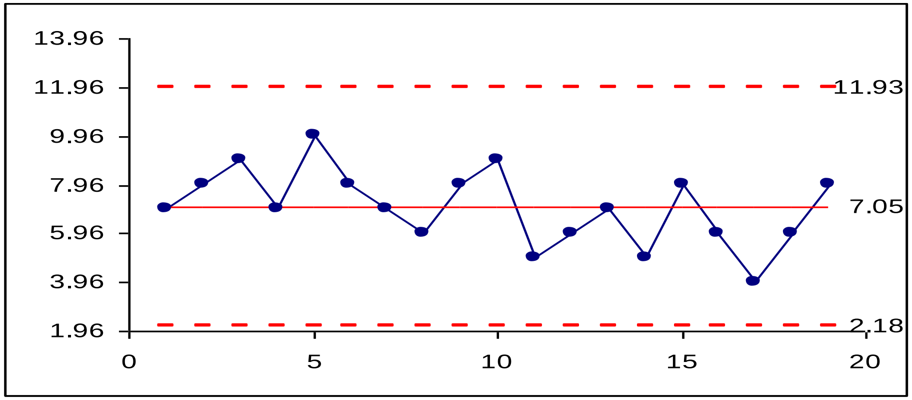
Note: Eliminating special cause variation can be one of the easiest ways to reduce variation and improve the process performance.

Control Charts – When to Use

- Define Phase – To establish a baseline of current process performance (metrics)
- Analyze Phase – After data collection & MSA, control charts are used to determine process variation (spread / standard deviation), location, normality and stability
- Control Phase – To ensure improvements have positively impacted process variation, location and stability. Also, monitor sustained gains over long term

Control Chart Terminology

- *Control* - operating within natural limits without undue impact from outside, extraneous, or "special" causes
- *Control Limits* - statistically calculated boundaries within which a process in control should operate.
  - Identify the **natural** bounds of the process
  - Based on the Voice of the Process
  - Unrelated to customer specifications
- *Control Chart* - a sequential time plot tracking process performance



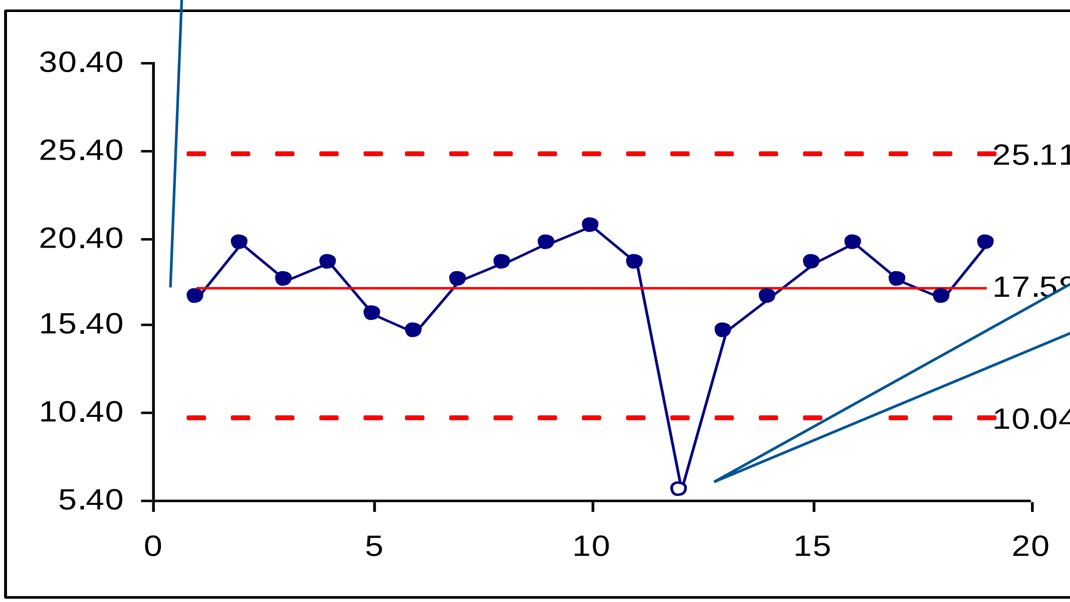
Control Chart Terminology

- Common Cause Variation – natural variation of a process
  - Consistent, stable, random variability within the process
  - Requires fundamental (systemic) improvement to reduce; usually more difficult to reduce
- Special Cause Variation – variation that is not natural to a process due to an outside influence ("special cause") that may temporarily or permanently alter the process performance unless identified and addressed.
  - Identified by changes in process performance, outliers, or unusual patterns in the data
  - Requires identifying process changes; usually easier to address and eliminate

Control Chart - Illustration

Time plot of sequential process measurements

Normal or expected range of measures



Out-of-control point

Control Limits vs. Spec Limits

Control Limits

- Defined based on process performance (+/- 3 estimated standard deviations from the mean).
- Help determine if your process is "in control" (without special cause variation).
- Plotted on control charts.
- Change when there is a verified, significant change to your process.
- Represent the voice of the process.

Customer Spec Limits

- Defined based on feedback from the customer(s).
- Help determine if your process is producing defects.
- Plotted on histograms (not control charts).
- Change when your customers say they do!
- Represent the voice of the customer.
- Determine product functional requirements

Control Charts – Data Types

Variable/Continuous (Measurable)

- **Processing Cycle Time (days, weeks, months)**
- **Customer Wait Time (seconds, minutes, hours)**
- **Can you think of other variable data types in your organization?**

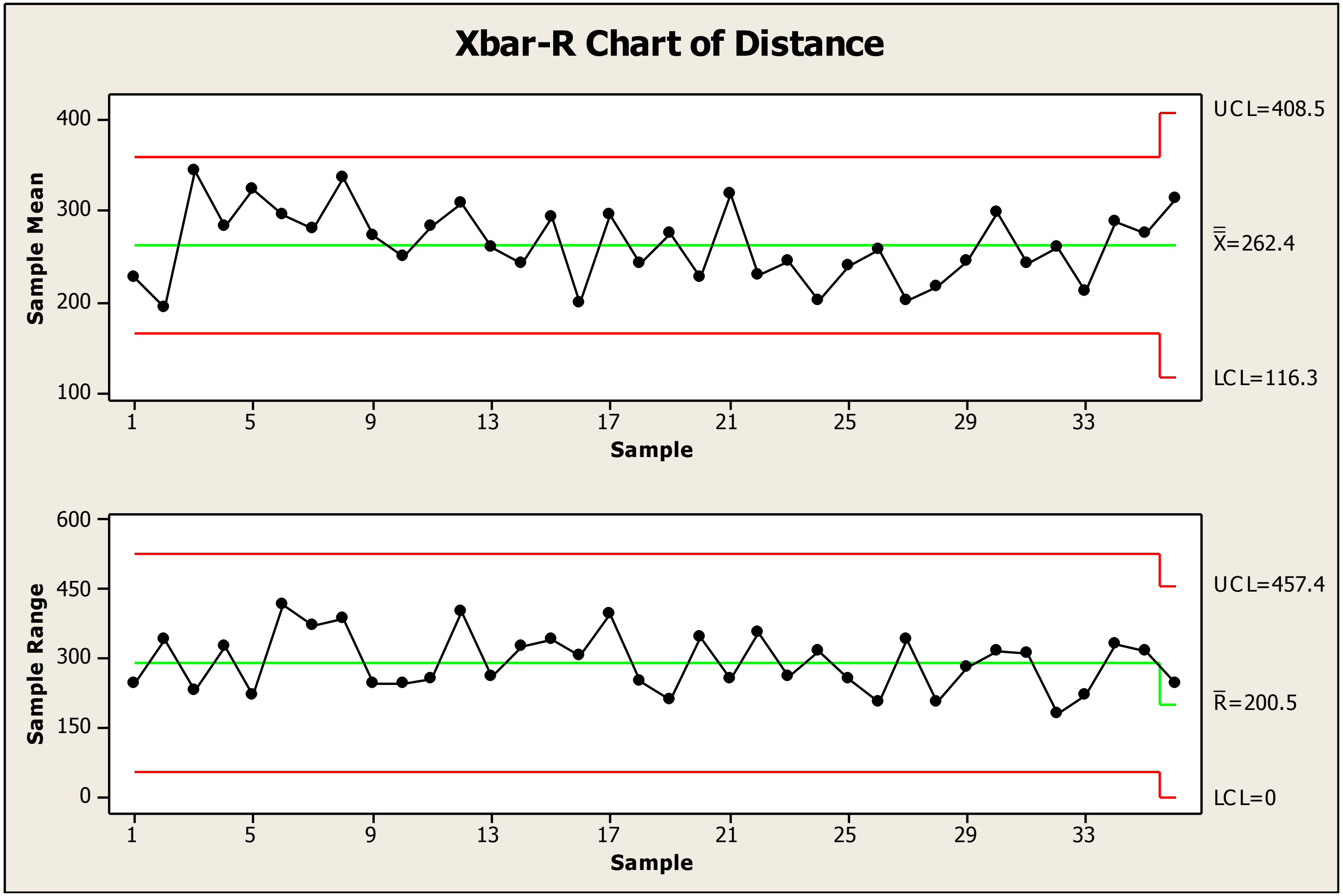
Attribute / Discrete (Defects)

- **Number of Errors on Patient Records (missing or incorrect information)**
- **Can you think of other attribute data types in your organization?**

Control Chart: Illustration

Common Cause Variation

Subgroup Variation



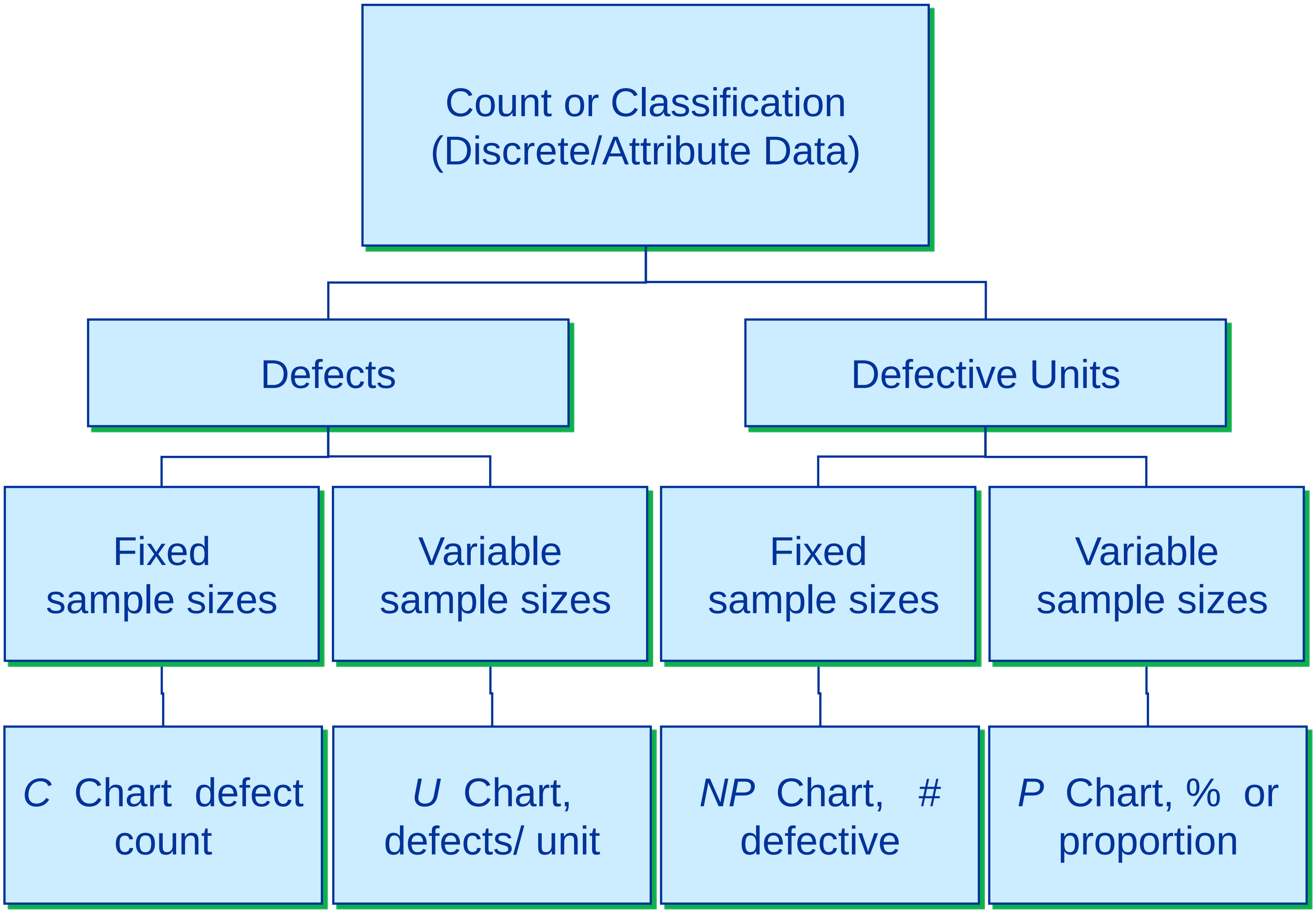
The Family of Control Charts

- Continuous/Variable data
  - X-bar/R charts for sample averages
  - ImR charts for individual items
  - X-bar/S charts for large samples using standard deviation
  - ***Always measurable with a tool***
    - Examples: stopwatch, caliper, scale
- Attribute/Discrete
  - p-chart for percent or proportions of defective items
  - np-chart for number of defective items
  - u-chart for defects per unit
  - c-chart for number of defects
  - ***Operational definitions are always required***
    - Examples: good/bad, pass/fail, correct/incorrect

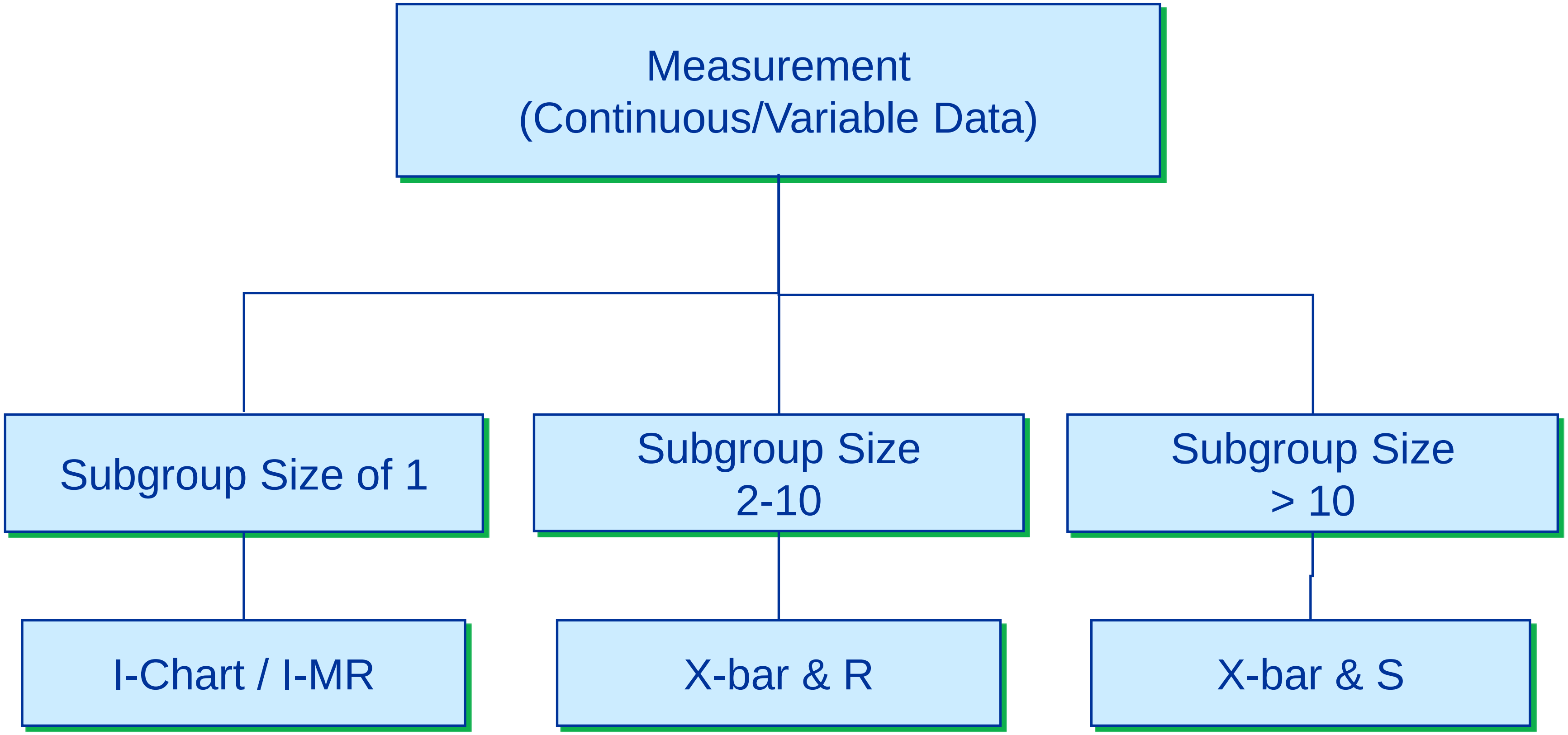
Control Chart Roadmap

Guidelines for Determining Control Chart Usage			
Type		Appropriate Data	Examples of Use
Discrete Data	c-Chart u-Chart	c = counts of relatively infrequent events. To chart defects with constant subgroup size. u = counts of relatively infrequent events. To chart defects per unit with constant or variable subgroup size.	Number of miss applied payments. Number of lost checks. Number of miss applied payments per week @ FC. Number of fields missing info. on loan app.
	p-Chart np-Chart	p-Chart: To chart proportion or percent defective with subgroup size constant or variable. np-Chart: To chart number of defective units with constant subgroup size. (**Note:** A defective may contain many defects.)	p-Chart: percent defective, percent of mis-routed mail items from FC (sample sizes may vary), percent of late loan payments. np-Chart: Number of defective applications per batch (sample sizes are constant).
Continuous Data	I-Chart I-MR Chart	Measurable data collected on individual items (i.e. the subgroup size is one at any one time). Individual charts are some of the easiest to create, and can be used in a wide variety of situations but require larger shifts to highlight or detect a change. Based on the standard normal distribution.	Cycle time for a process (the item may be a single loan). Amount of money used in the ATM per day. Loan interest rates per day.
	X bar and Range Charts	X-Bar: displays the subgroup average. Based on standard normal distribution. R: range (variation) within & between the subgroups. X-Bar and R Charts should be used in conjunction to determine whether a process is in control.	X-Bar: Average length of time customers wait to be served (multiple customers used). Cycle time for a process (in this case, a group of loans may be monitored and the average time and range tracked).

Discrete/Attribute Chart Decision Tree



Continuous/Variable Chart Decision Tree



P-Chart

- Used whenever monitoring proportion or percent defective
- Some uses of the p-chart in transactional applications are:
  - Account errors
  - Defective patient records
  - Proportion of statements with errors
  - Missing items

P-Chart: Exercise

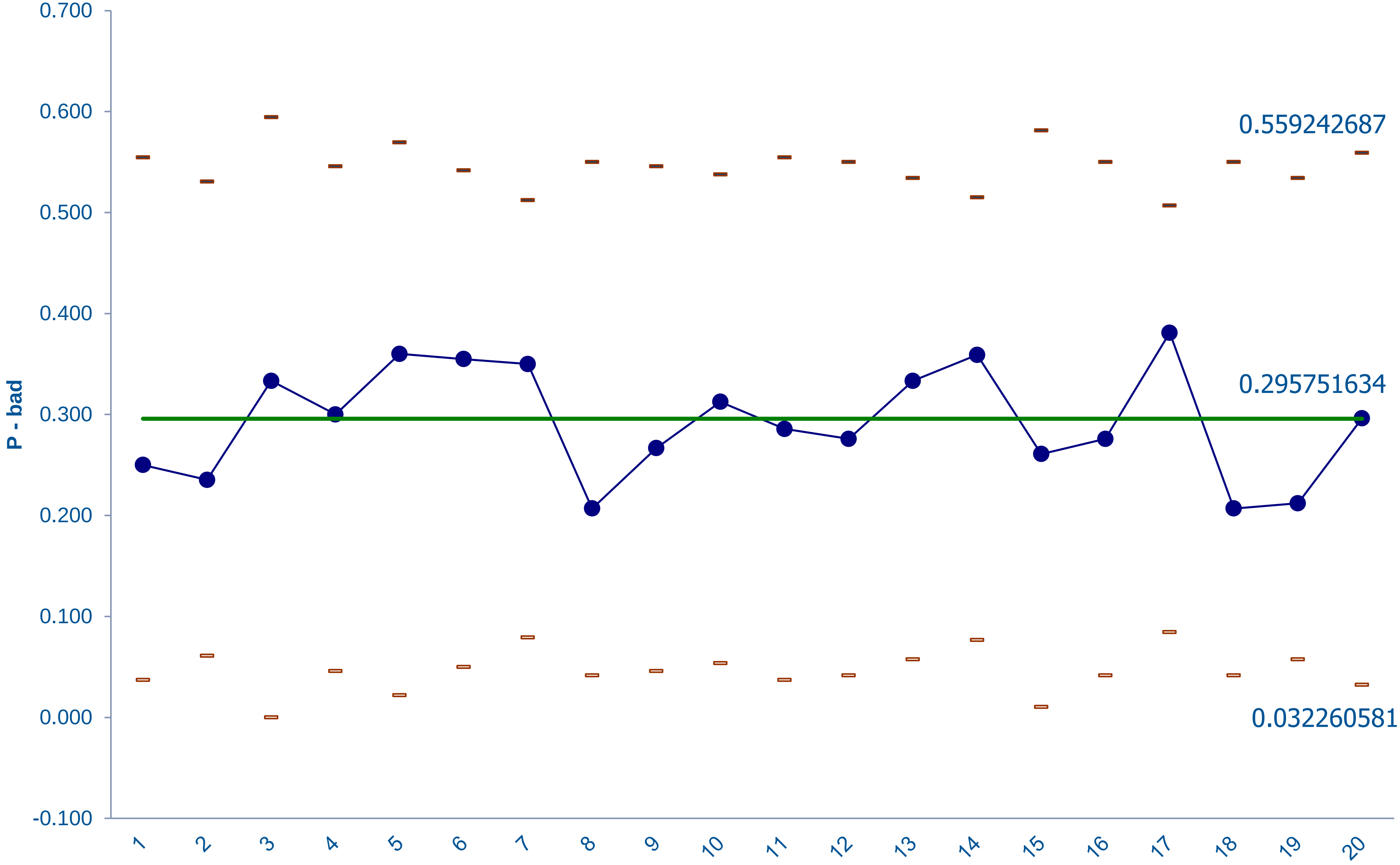
A Registrar processes patient records and sends them over to Pre-Op. Construct a p-chart and see what percent of records are defective.

Day	1	2	3	4	5	6	7	8	9	10
Records	28	34	21	30	25	31	40	29	30	32
Bad	7	8	7	9	9	11	14	6	8	10

Day	11	12	13	14	15	16	17	18	19	20
Records	28	29	33	39	23	29	42	29	33	27
Bad	8	8	11	14	6	8	16	6	7	8

As the Patient Registrar Manager,
what are your next steps?

P-Chart for Errors



U-Chart

- Used whenever monitoring number of defects per unit.
- Some uses of the U-Chart in transactional applications are:
  - Number of account errors per customer or batch.
  - Number of defects on each application processed.
  - Number of errors on each patient record processed .

U-Chart: Exercise

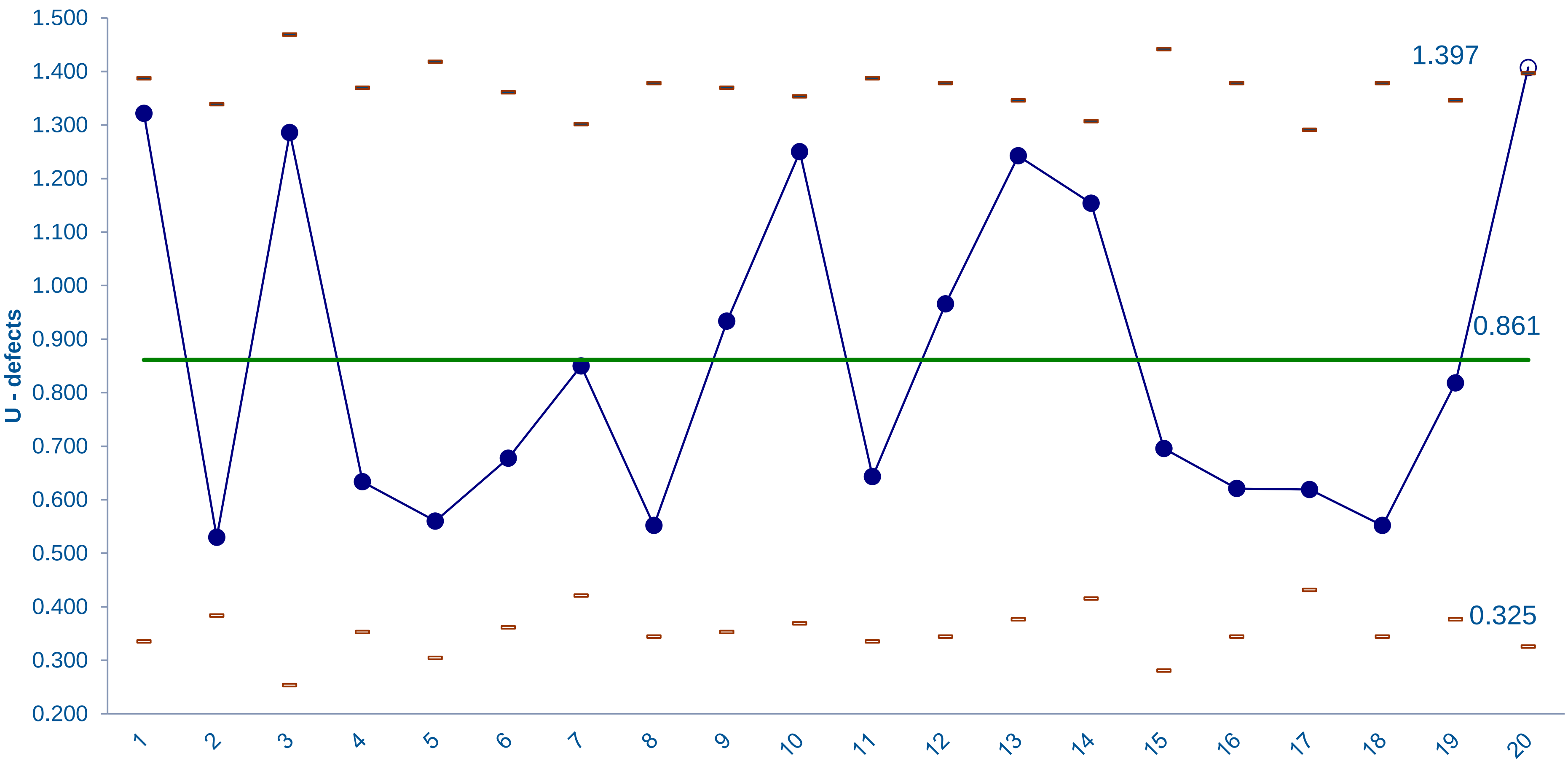
Now that you now the percent of defective patient records being received from your Registrar, how many defects per record are we getting?

Day	1	2	3	4	5	6	7	8	9	10
Records	28	34	21	30	25	31	40	29	30	32
Defects	37	18	27	19	14	21	34	16	28	40

Day	11	12	13	14	15	16	17	18	19	20
Records	28	29	33	39	23	29	42	29	33	27
Defects	18	28	41	45	16	18	26	16	27	38

As the Pre-Op Manager,
what are your next steps?

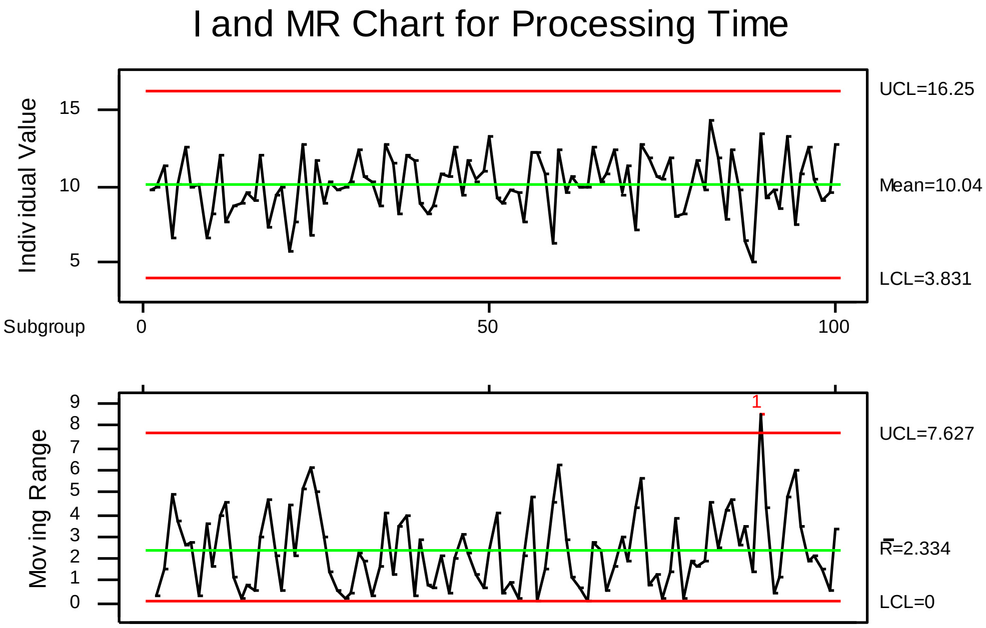
U-Chart: Exercise



I-MR Chart

(Individual and Moving Range)

I-MR chart is appropriate for continuous data and focuses on the variation between individual measures.



Usage when:

There is no basis for subgrouping.

Each measurement represents one batch.

Production rate is slow such that measurements are easy to gather or widely spaced in time.

ImR-Chart: Exercise

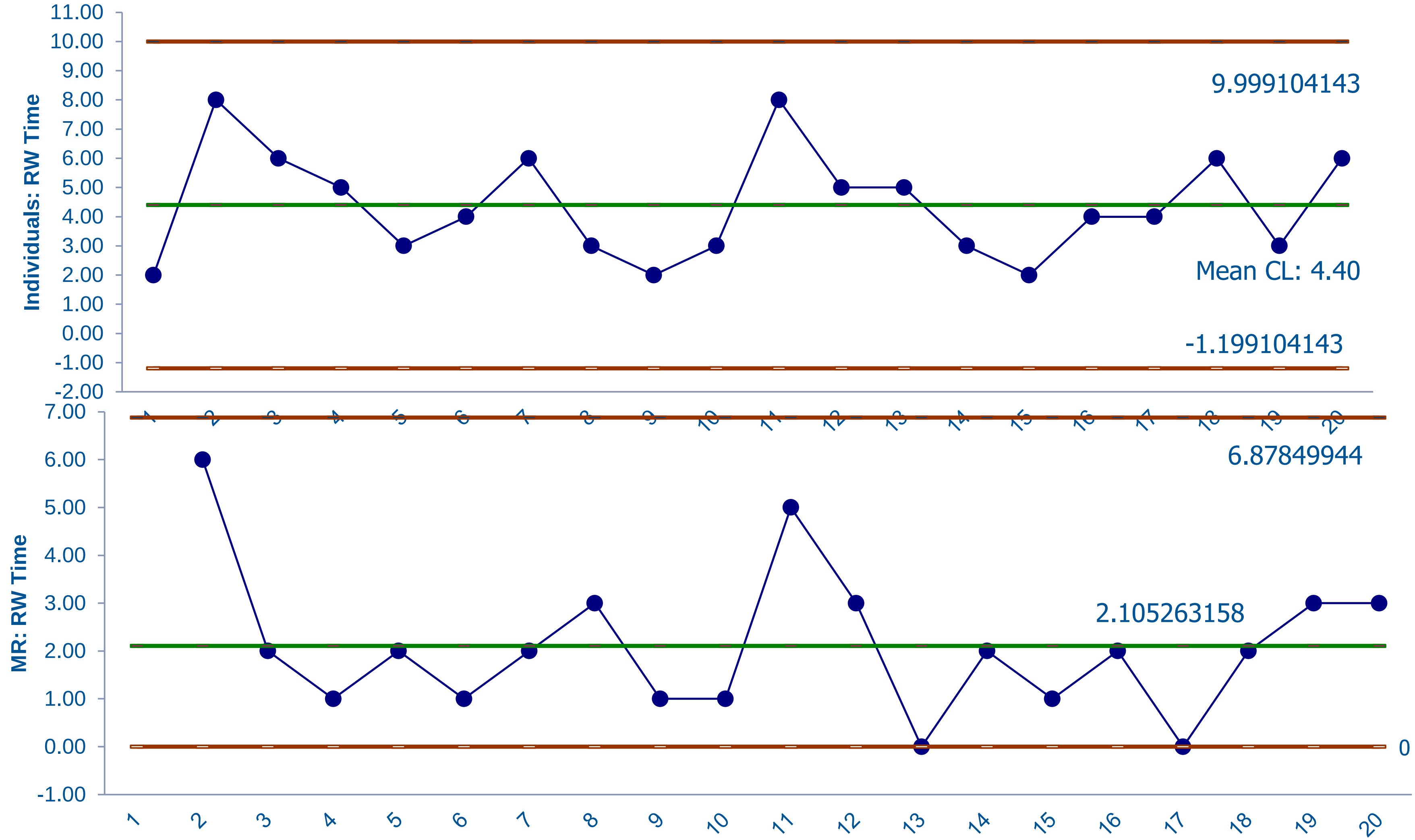
Now that you now how many defects per record you are getting, how much time is your team spending per week reworking the mistakes?

Day	1	2	3	4	5	6	7	8	9	10
Records	28	34	21	30	25	31	40	29	30	32
RW Time (hours)	2	8	6	5	3	4	6	3	2	3

Day	11	12	13	14	15	16	17	18	19	20
Records	28	29	33	39	23	29	42	29	33	27
RW Time (hours)	8	5	5	3	2	4	4	6	3	6

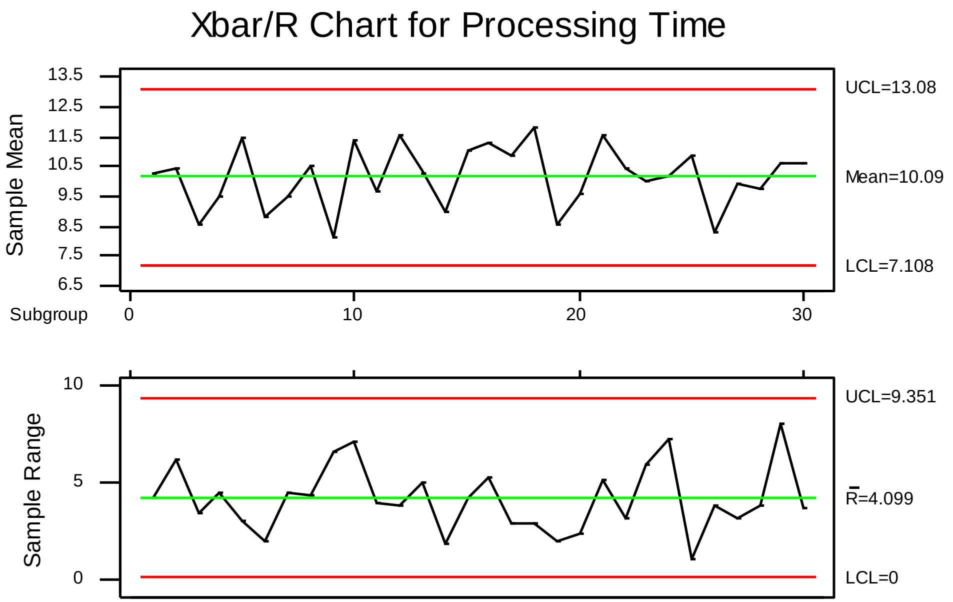
As the Pre-Op Manager,
what are your next steps?

ImR-Chart: Exercise – RW Time



Xbar-R Chart

Xbar-R chart is appropriate for continuous data when it is practical to collect frequent samples of subgroups.



Most sensitive (powerful) chart for tracking changes in the mean.

R chart:

Shows changes in the "within" subgroup variation.

Asks "Is the variation in the measurements within subgroups stable?"

X-bar chart:

Shows changes in the average value of the process.

Asks "Is the variation between the averages of the subgroups more than that predicted by the variation within the subgroups?"

Contact Us

- SixSigmaTV.Net
- JGray@SixSigmaTV.Net (Master Black Belt)
- SPhinney@SixSigmaTV.Net (Master Black Belt)
- BecomeaSponsor@SixSigmaTV.Net
- RequestaTraining@SixSigmaTV.Net
- SenddataandQuestions@SixSigmaTV.Net