Total Quality Management and Six Sigma

Post Graduate Program 2014-15

Session 2

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Recap

- Quality definitions
- History of quality thinking
- Present era challenges
- Group formation

Agenda

- Statistical Process Control
- Process Control at Polaroid Case

The process view

- The Red Bead experiment
  - https://www.youtube.com/watch?v=ckBfbvOXDvU

The process view

- Service/Manufacturing processes are characterized by
  - Output: Service outcome that determines service quality
  - Input: Customer inputs, Resources, employees
  - Variability: Dispersion in output
    - **Natural causes**: Non-controllable; inherent variability in the system, noise, usually minor
    - **Assignable causes**: Controllable, bring about a fundamental change on the nature of the process, causes considerable impact on quality

Pre-requisites

- Mean and standard deviation
- Random variables and Probability distribution
  - Normal distribution
- Type 1 and Type 2 errors
- Central limit theorem

Process control charts

- Information: Monitor process variability over time
- Control limits: Average + z Normatl variability
  - $z = 3$
- Decision Rule: Ignore variation outside "abnormal"
- Errors: Type 1 and Type 2

Types of Data

- Variable data
  - X-bar and R charts
  - Time, customer satisfaction scores
- Attribute data
  - p-charts and c-charts
  - Good/bad, yes/no, number of errors!

Rest of the discussion

- Different charts have different purposes
- Constructing a control chart
- Knowing when things have gone wrong
- Process capability
- Six sigma!

Constructing a control chart

- Decide what to measure and count
- Collect sample data
- Calculate and plot control limits on the control chart
- Determine if data is in control
- If non-random variation is present, fix the problem and recalculate control limits.

Example: Control Charts for Variable Data

Sample	Ambulance response time (in minutes) 1	2	3	4	5	$\bar{X}$	R
1	5.02	5.01	4.94	4.99	4.96	4.98	0.08
2	5.01	5.03	5.07	4.95	4.96	5.00	0.12
3	4.99	5.00	4.93	4.92	4.99	4.97	0.08
4	5.03	4.91	5.01	4.98	4.89	4.96	0.14
5	4.95	4.92	5.03	5.05	5.01	4.99	0.13
6	4.97	5.06	5.06	4.96	5.03	5.01	0.10
7	5.05	5.01	5.10	4.96	4.99	5.02	0.14
8	5.09	5.10	5.00	4.99	5.08	5.05	0.11
9	5.14	5.10	4.99	5.08	5.09	5.08	0.15
10	5.01	4.98	5.08	5.07	4.99	5.03	0.10
						50.09	1.15

Constructing A Mean Chart

$$UCL_{\bar{X}} = \bar{\bar{X}} + A_2\bar{R} = 5.01 + (0.58)\,(.115) = 5.08$$

$$LCL_{\bar{X}} = \bar{\bar{X}} - A_2\bar{R} = 5.01 - (0.58)\,(.115) = 4.94$$

where $\bar{\bar{X}}$ = average of sample means = $\Sigma\,\bar{X} / n$

= 50.09 / 10 = 5.01

$\bar{R}$ = average range = Σ R / k

= 1.15 / 10 = .115

Constructing an Range Chart

$$UCL_R = D_4 \bar{R} = (2.11)\ (.115) = 2.43$$

$$LCL_R = D_3 \bar{R} = (0)\ (.115) = 0$$

where $\bar{R} = \Sigma R / k = 1.15 / 10 = .115$

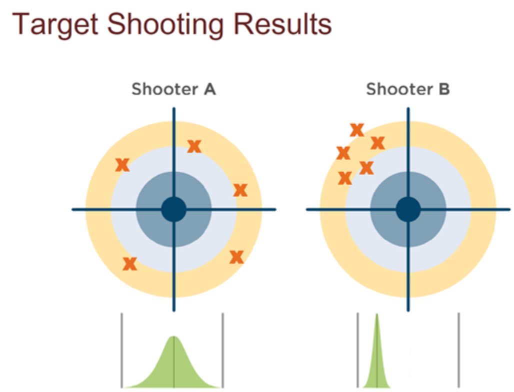
k = number of samples = 10

R = range = (largest - smallest)

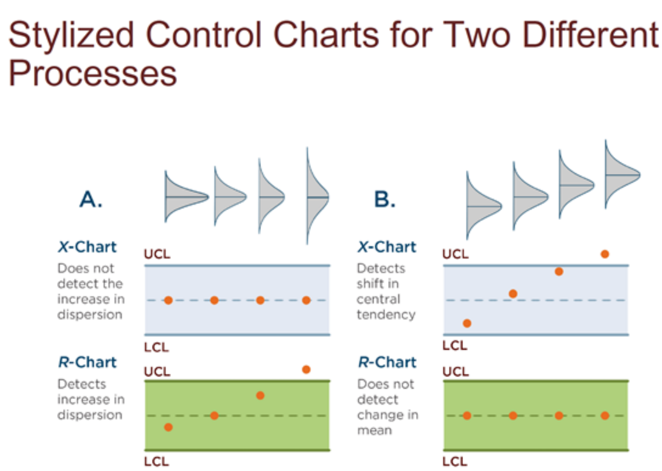
3σ Control Chart Factors

Sample size	$\bar{X}$-chart	R-chart	
n	**A_2**	**D_3**	**D_4**
2	1.88	0	3.27
3	1.02	0	2.57
4	0.73	0	2.28
5	0.58	0	2.11
6	0.48	0	2.00
7	0.42	0.08	1.92
8	0.37	0.14	1.86

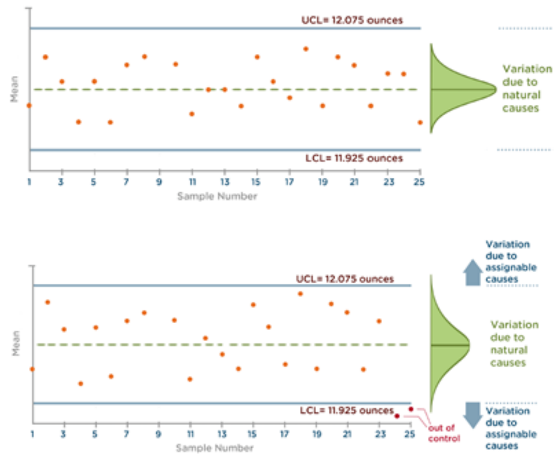
Utility of X-bar and R chart



Utility of X-bar and R chart



Output



Other charts

- P-charts
  - Calculate percentage defectives in a sample
  - an item is either good or bad
  - Based on binomial distribution

– p = number defective / sample size, n

– $\bar{p} = \dfrac{\text{total no. of defectives}}{\text{total no. of sample observations}}$

$$UCL_p = \bar{p} + 3\sqrt{\bar{p}(1-\bar{p})/n}$$

$$LCL_p = \bar{p} - 3\sqrt{\bar{p}(1-\bar{p})/n}$$

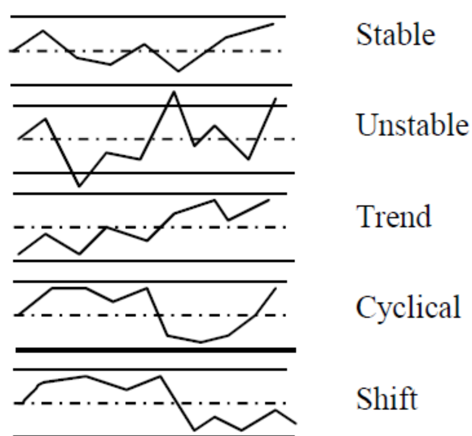
Other charts

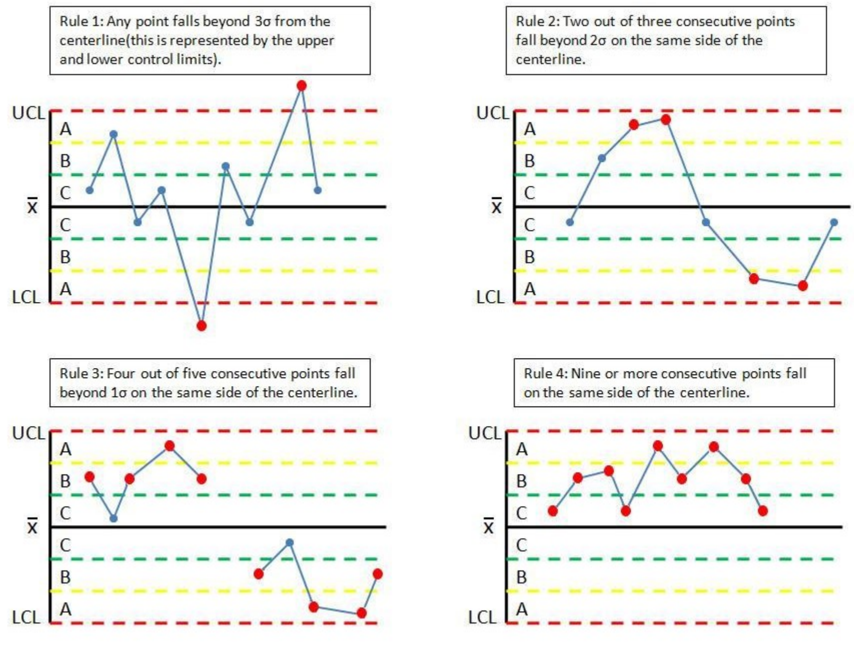
- c Charts
  - Count number of defects in an item
  - Based on poisson distribution

  - c = number of defects in an item
  - $\bar{c} = \dfrac{\text{total number of defects}}{\text{number of samples}}$
  - $UCL_c = \bar{c} + 3\sqrt{\bar{c}}$

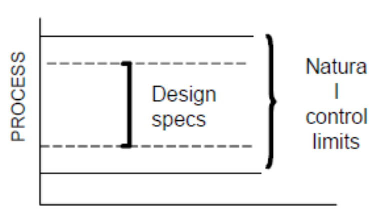
    $LCL_c = \bar{c} - 3\sqrt{\bar{c}}$

Performance variation patterns

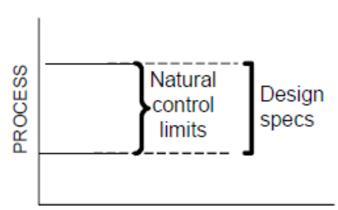




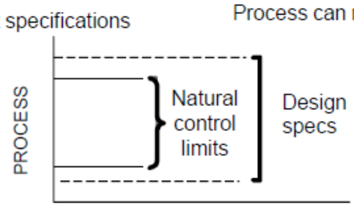
Process capability



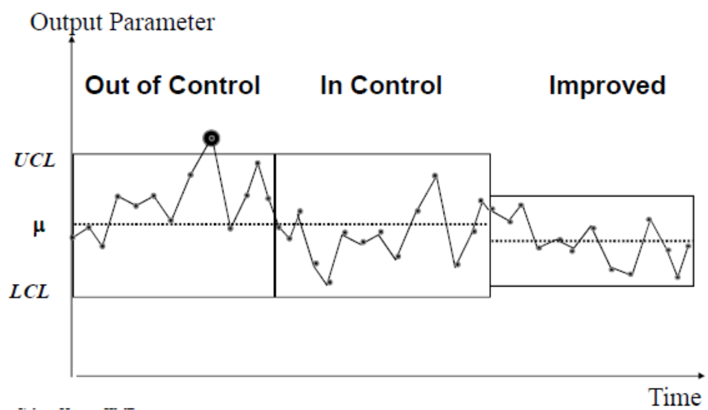
Process cannot meet specifications



Process can meet specifications



From Control to improvement



Sigma statistics

1σ	317 per thousand
2σ	45 per thousand
3σ	2 per thousand
4σ	63 per million
5σ	574 per billion
6σ	2 per billion
7σ	0.3 per billion

THANK YOU