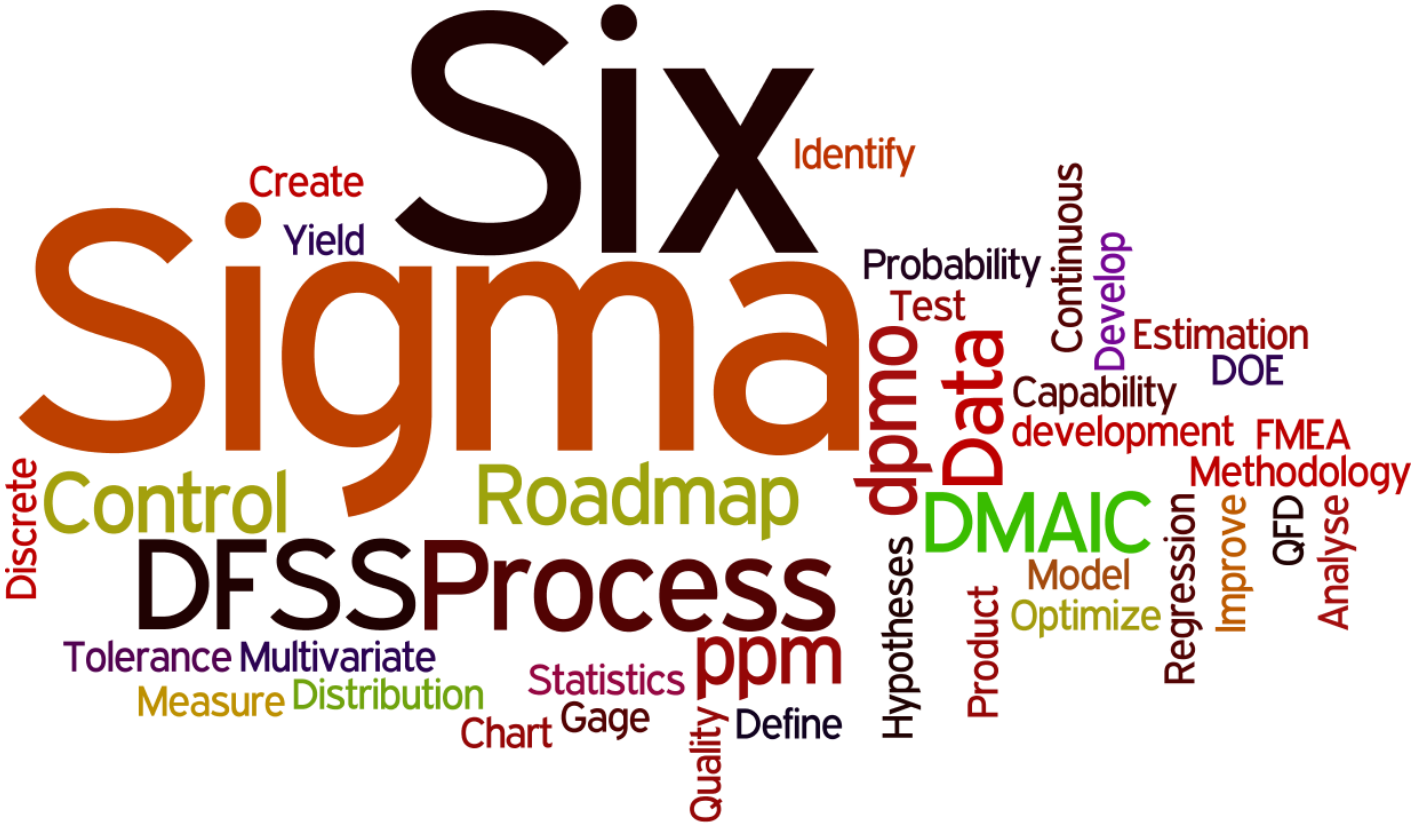


SPC

Statistical Process Control / Variables /Attributes

Green Belt´s Training | Jun 2021

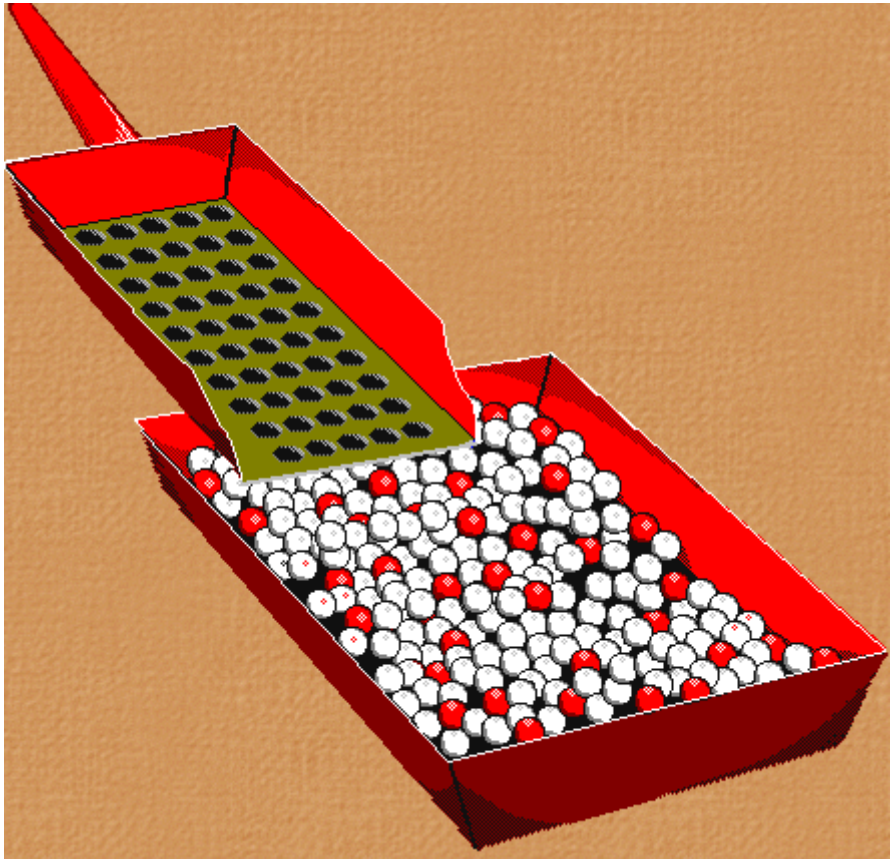
Statistical Process Control

Walter A. Shewhart

Walter A. Shewhart

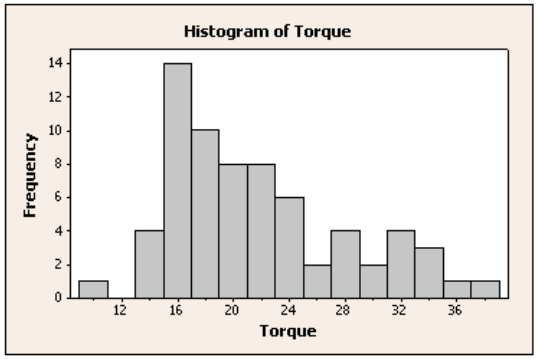
Born	March 18, 1891 New Canton, Illinois
Died	March 11, 1967 (aged 75)
Fields	physics, engineering, statistics
Institutions	Western Electric
Alma mater	University of Illinois, University of California, Berkeley

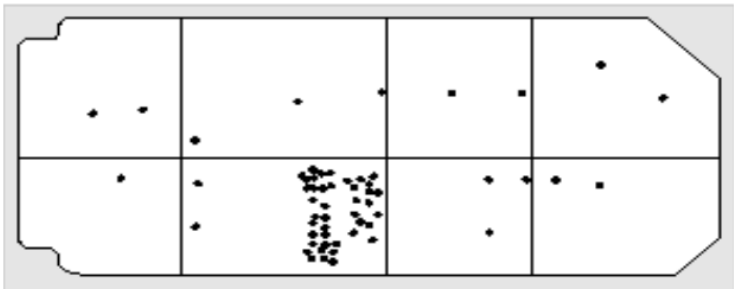
(See on the internet:
Demming´s Red Bead Experiment)

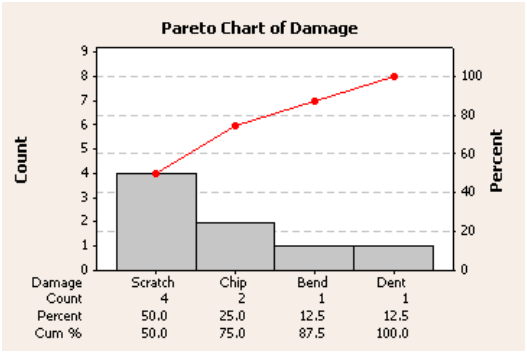


https://www.youtube.com/watch?v=JeWTD-0BRS4

7 SPC Tools





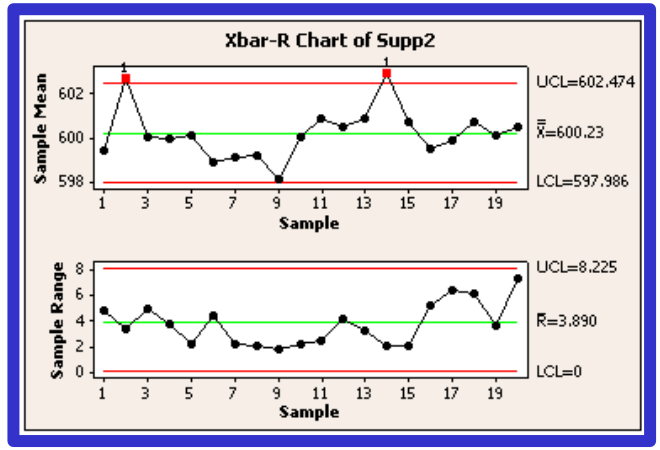


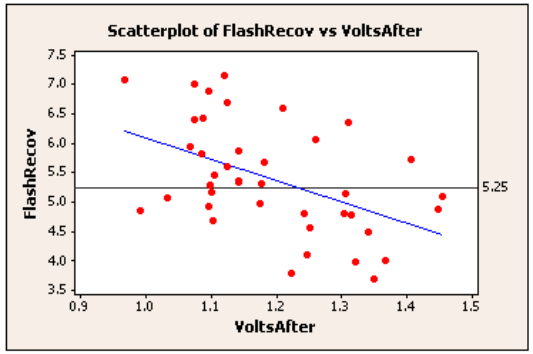
1. Histogram
2. Pareto chart
3. Cause-and-effect diagram
4. Defect-concentration diagram
5. Control chart
6. Scatter diagram
7. Check sheet

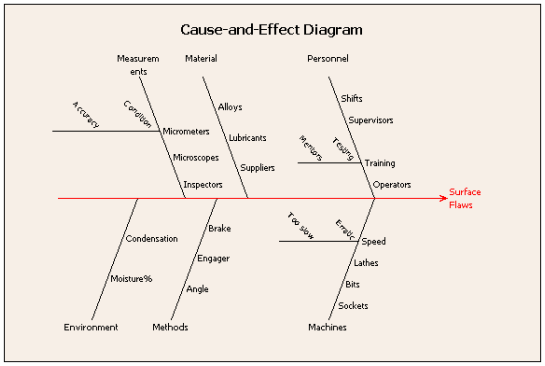
Telephone Interruptions

Reason	Day					
	Mon	Tues	Wed	Thurs	Fri	Total
Wrong number	𝍸	II	I	𝍸	𝍸 II	20
Info request	II	II	II	II	II	10
Boss	𝍸	II	𝍸 II	I	IIII	19
Total	12	6	10	8	13	49

Check Sheet Example







Control

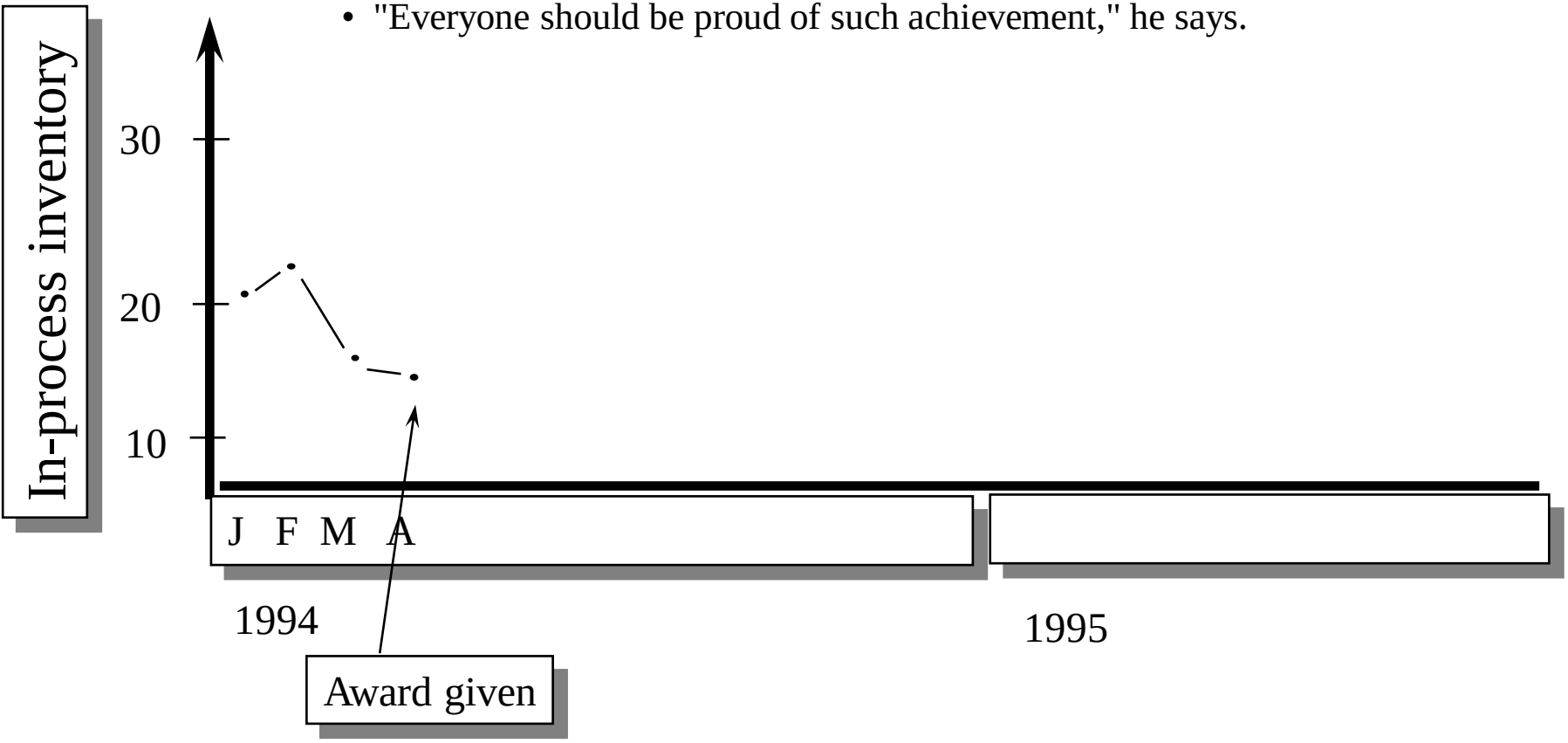
How to maintain improvement?

"Some organizations went bankrupt because they let their manufacturing processes (or services) proceed without constant monitoring."

Scenes from a company 1/5

April 1994:

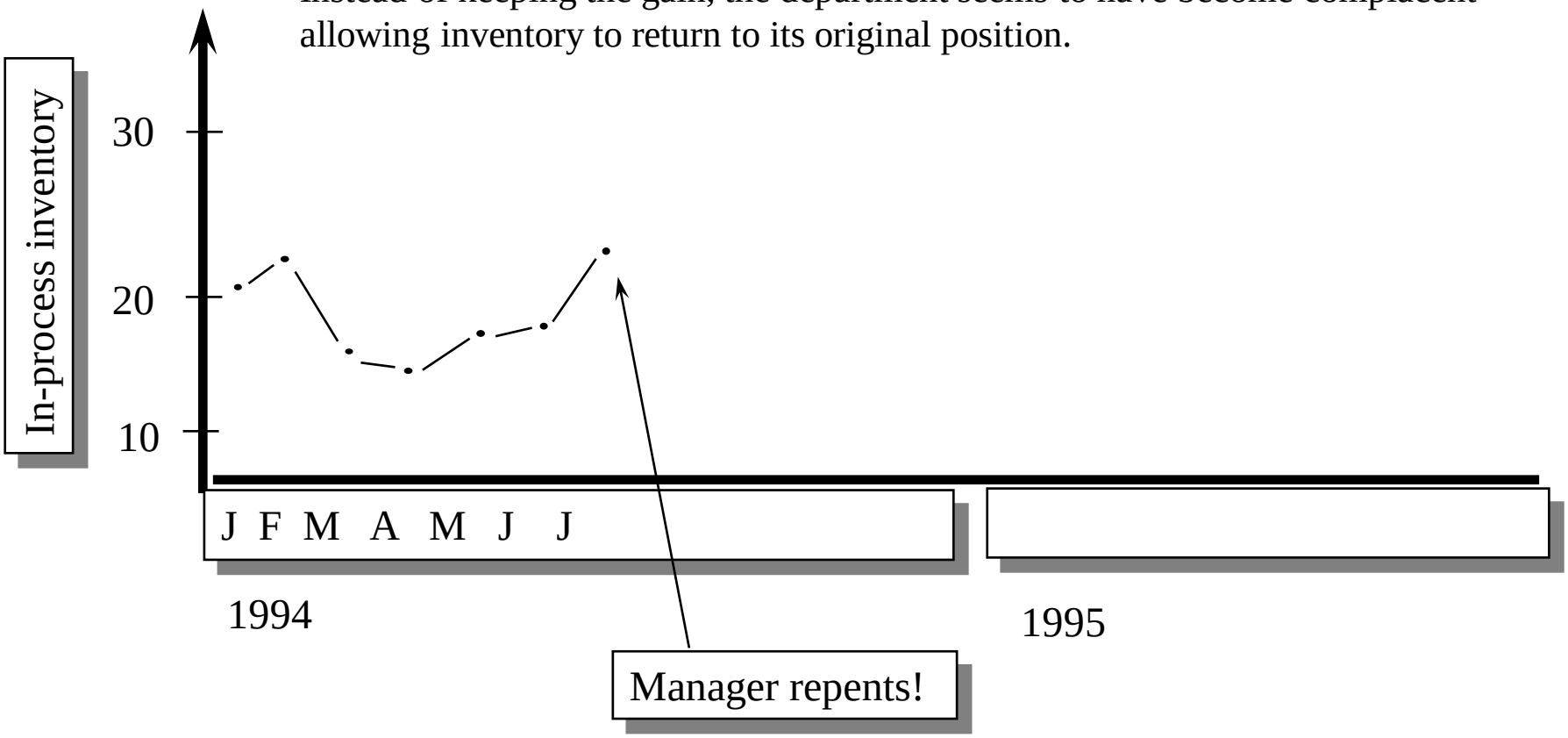
- "The in-process inventory (the lower the better) is at a low of 15. A record for the last 3 years.
- The manager delivers an award to your department in view of this achievement.
- Ceremony at the company cafeteria: pizza and refreshments for everyone!
- "Everyone should be proud of such achievement," he says.



Scenes from a company 2/5

July 1994:

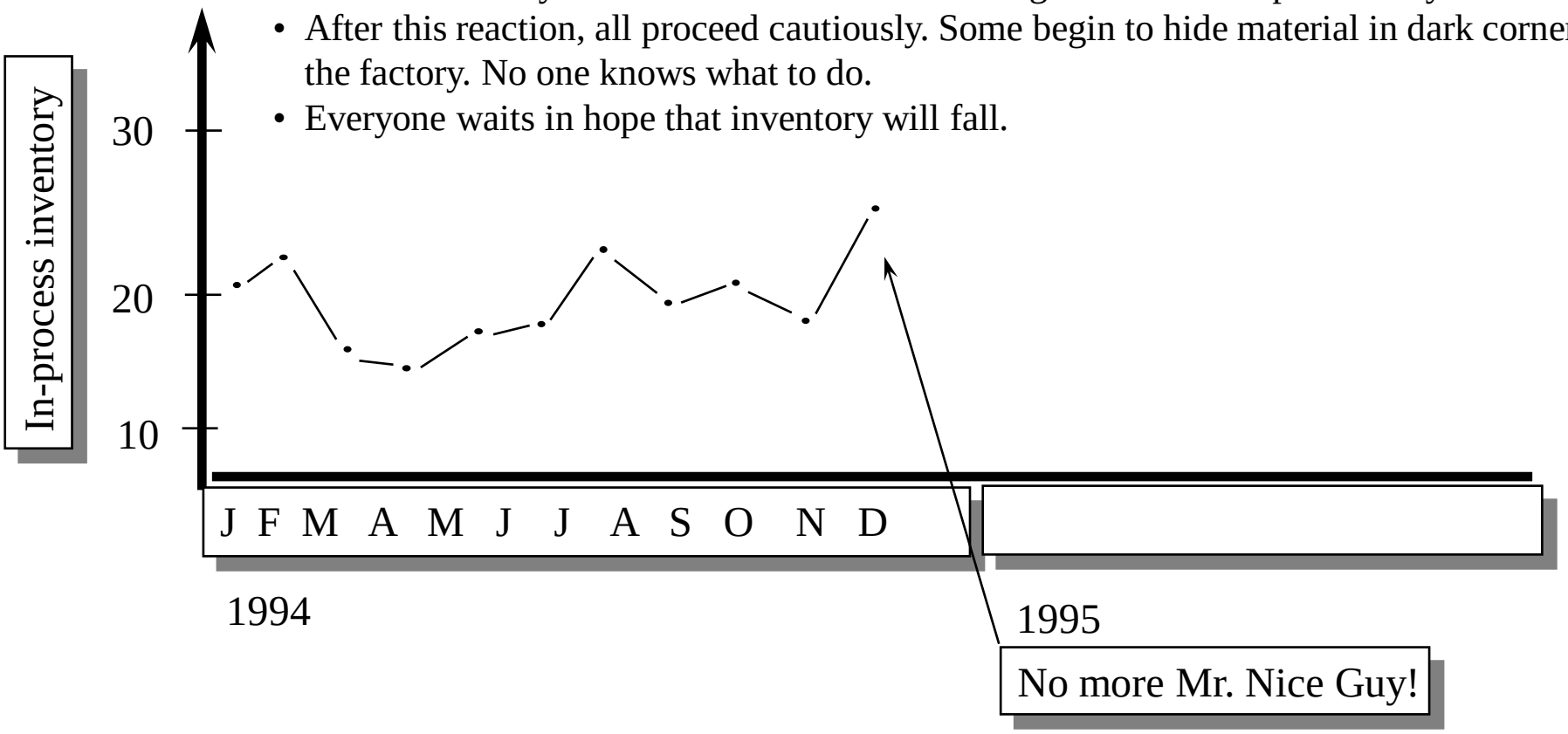
- 3 consecutive months of inventory increase.
- The manager would like to be able to withdraw the prize.
- "The recognition seems to have given no result."
- Instead of keeping the gain, the department seems to have become complacent - allowing inventory to return to its original position.



Scenes from a company 3/5

Nov. 1994:

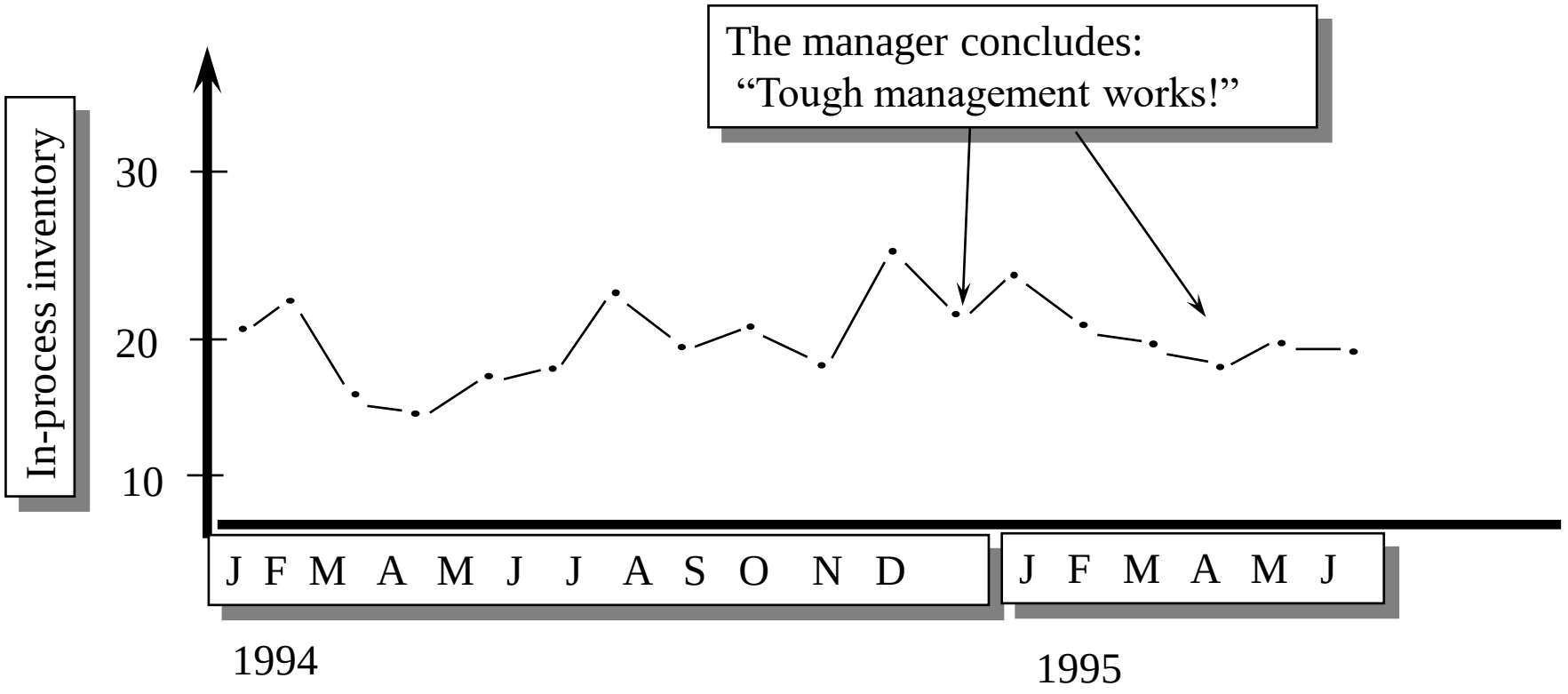
- The in-process inventory reaches 26 !!!
- The manager decides to "kick some asses" and take note of some names. This group needs a tough manager! No more Mr. Nice Guy!"
- He talks to everyone and demands that something be done to keep inventory levels down.
- After this reaction, all proceed cautiously. Some begin to hide material in dark corners in the factory. No one knows what to do.
- Everyone waits in hope that inventory will fall.



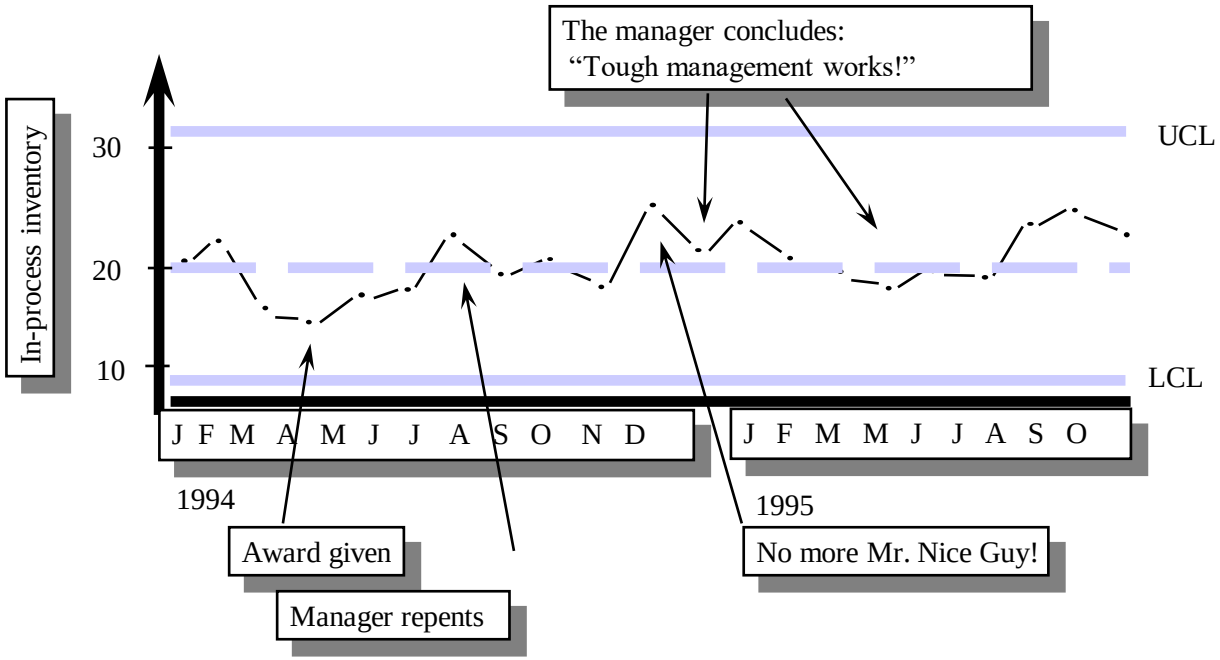
Scenes from a company 4/5

June 1995:

- Since the end of last year, the manager has noticed reduced inventory levels. "Things are getting better!", He thinks.
- What he learned (since little was done to change the system): “Tough management works"



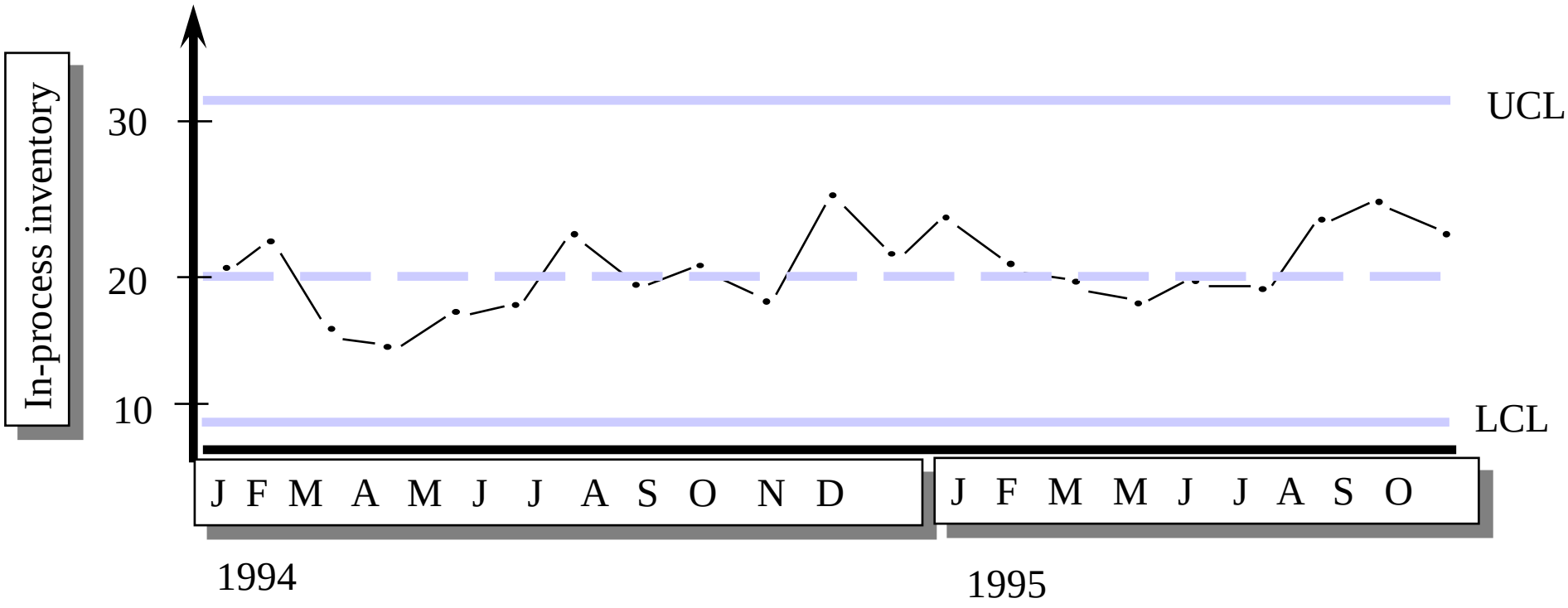
Scenes from a company 5/5



- **Not knowing how to interpret variation is one of the most common problems in all productive processes**

Typical errors

- Interpret some high and low points as indicators of the State of the Process;
- Understand an unpredictable process as predictable;
- Do not differentiate common causes and special causes of variation



Causes of Variation

Causes of Variation: Special (sporadic) and Common (permanent)

Common Cause X Special Cause

"Chronic" or "common" causes …
- Built into the process
- Generate a consistent overall pattern
- And level of inefficiency
- Harder to discover and evaluate
- Often imperceptible to people within the process
- Account for most of variation in manufacturing
- May require management to correct
- Advanced tools may be required to attack them

"Special" or "assignable" causes …
- Not built into the process
- Not always present
- Not uncommon as a group
- Presence can be detected statistically
- Easier to identify
- Can be removed by "local" action
- Cause less manufacturing problems than do common causes
- Often unpredictable
- Mask common-cause variation

Generally, 85% of variation problems are due to common causes

Common and Special causes of variation

Examples of **special causes** of variation

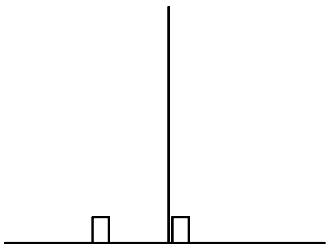
- Lot of raw material with problem
- Occasional equipment deregulation
- Breaking of measuring equipment
- Human or behavioral failures

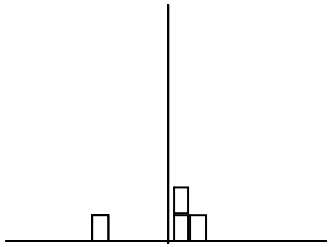
Examples of **common causes** of variation

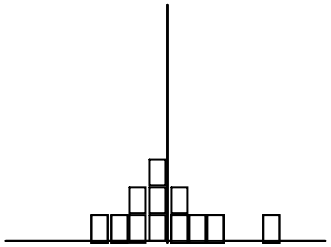
- Systematic purchase of materials with low quality
- Lack of training
- Lack of standardization of operations

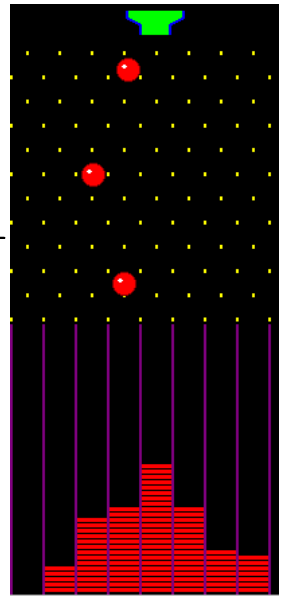
PQ Model

The outputs of all processes (and products) vary

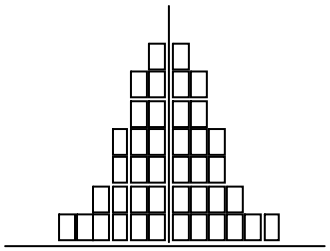


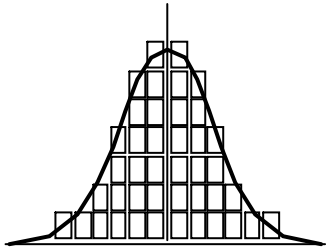


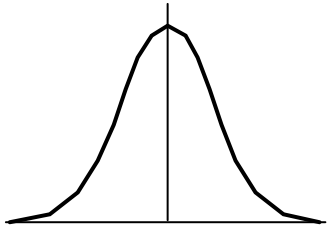




but, in the absence of special causes, they form a pattern

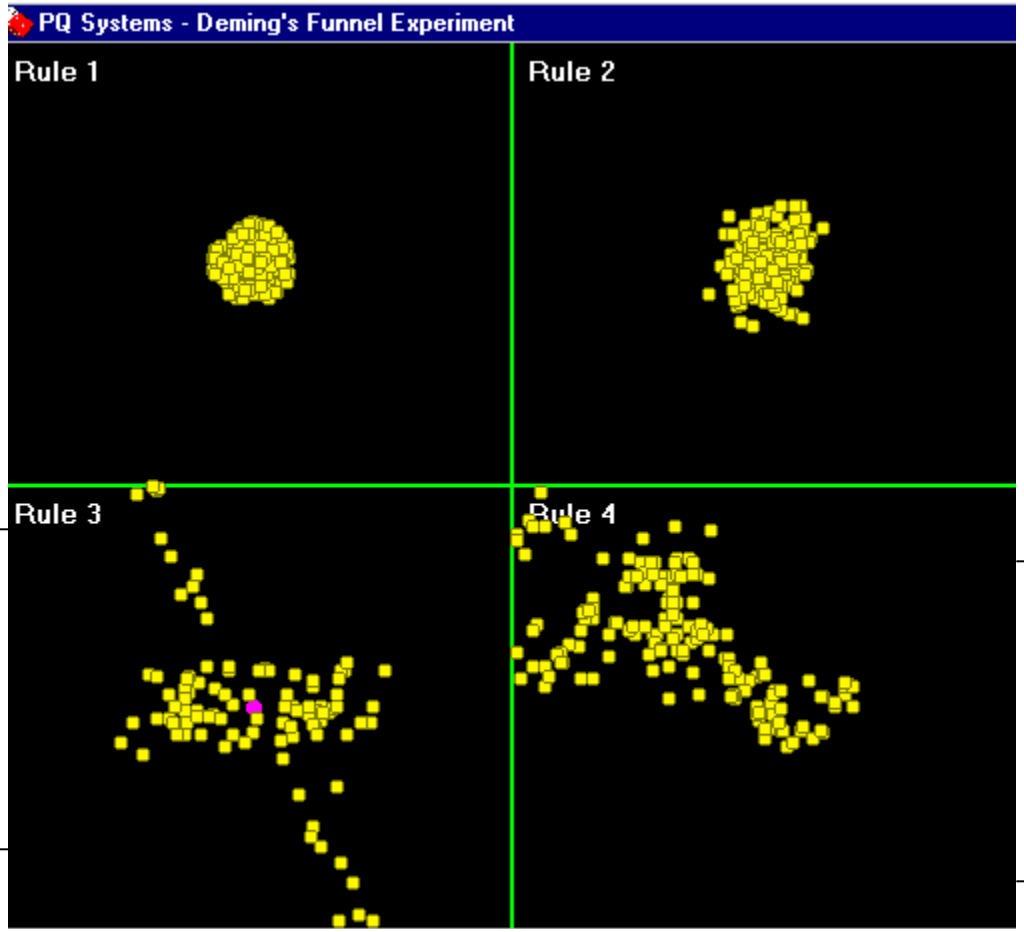


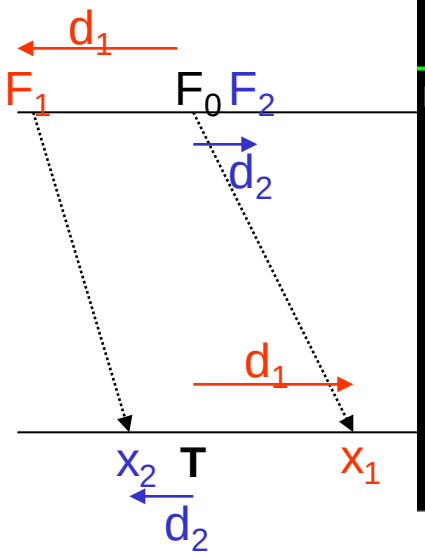


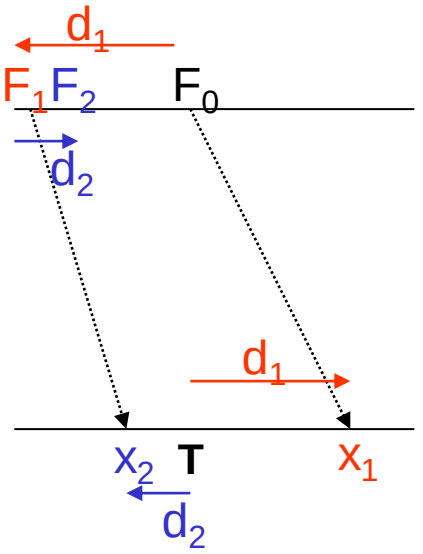


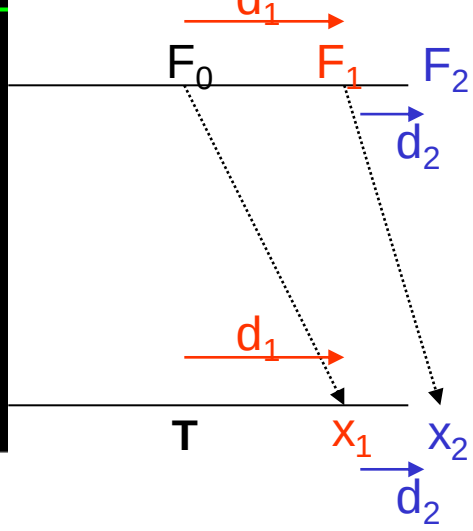
Demming´s Experiment

No adjusting









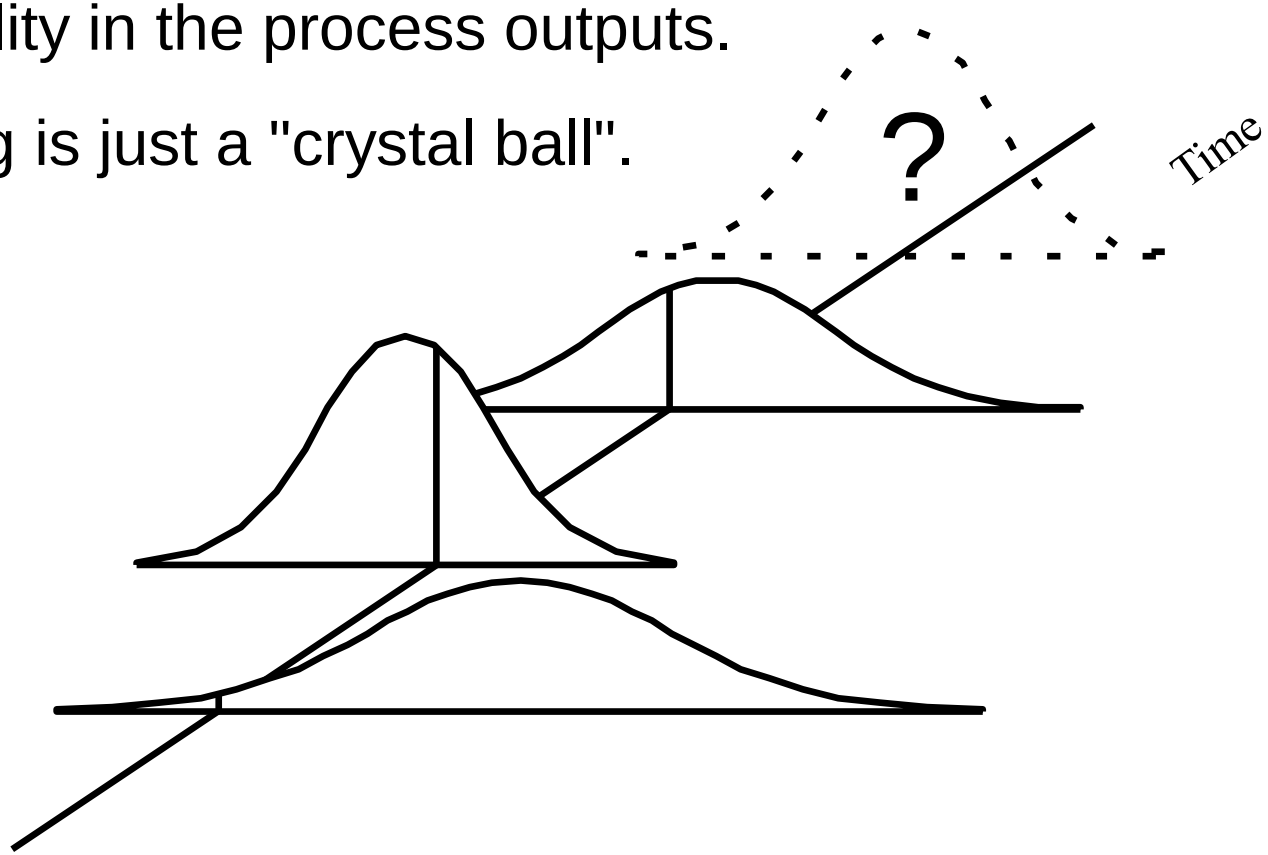
Do not Exaggerate in Adjustments!

Nashua Corp had problems with a coating machine and considered spending up to a million dollars to replace it. The machine had been working well with a stable process, but samples were taken too frequently, making adjustments based on the results. These super-adjustments, called tampering, caused deviations from a distribution that had been considered good. The effect was an increase in the number of defects. When he studied the process, statistician and quality control technician W. Edwards Deming recommended that no adjustments be made unless there was a signal that the process had shifted to the point of becoming unstable. The company performed better without adjustments than with too many of them.

Forecasting

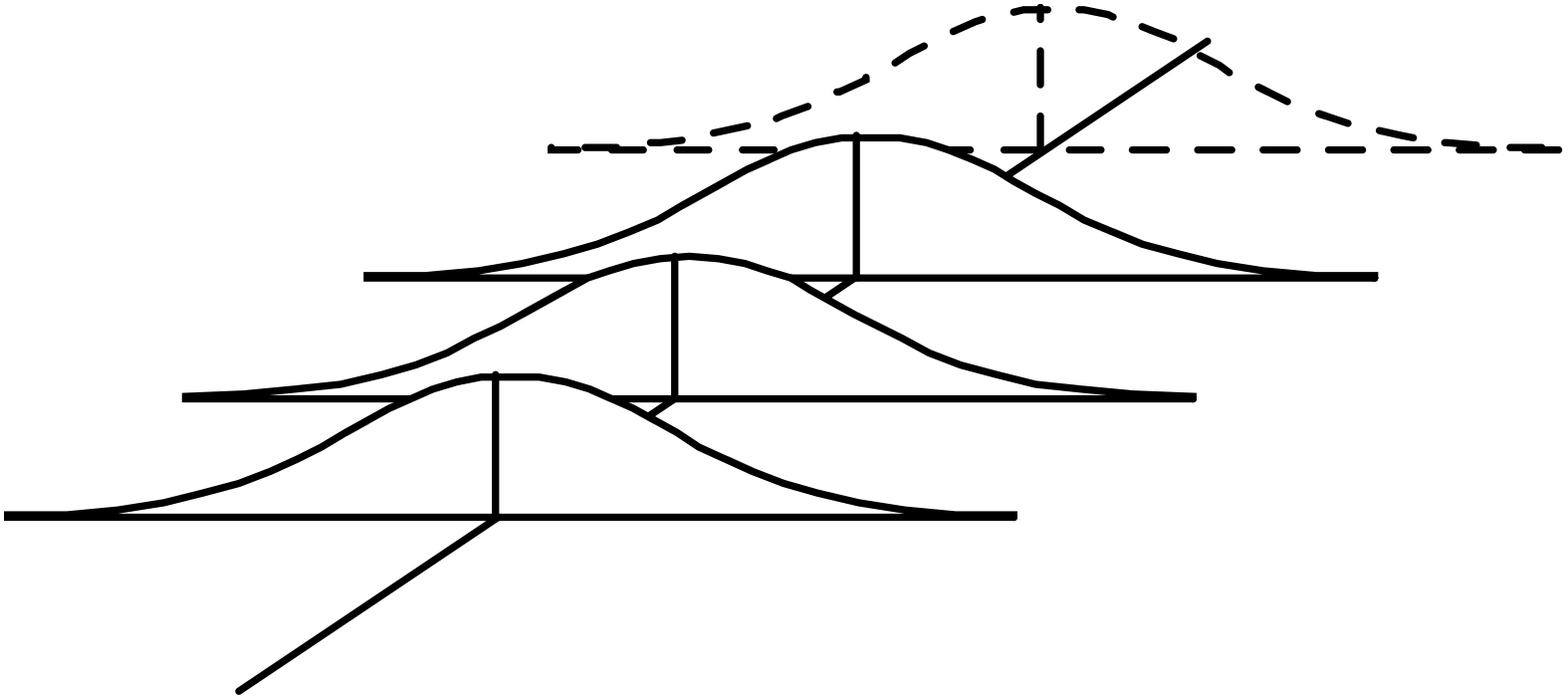
When special (and common) causes are present, there is no predictability in the process outputs.

Everything is just a "crystal ball".



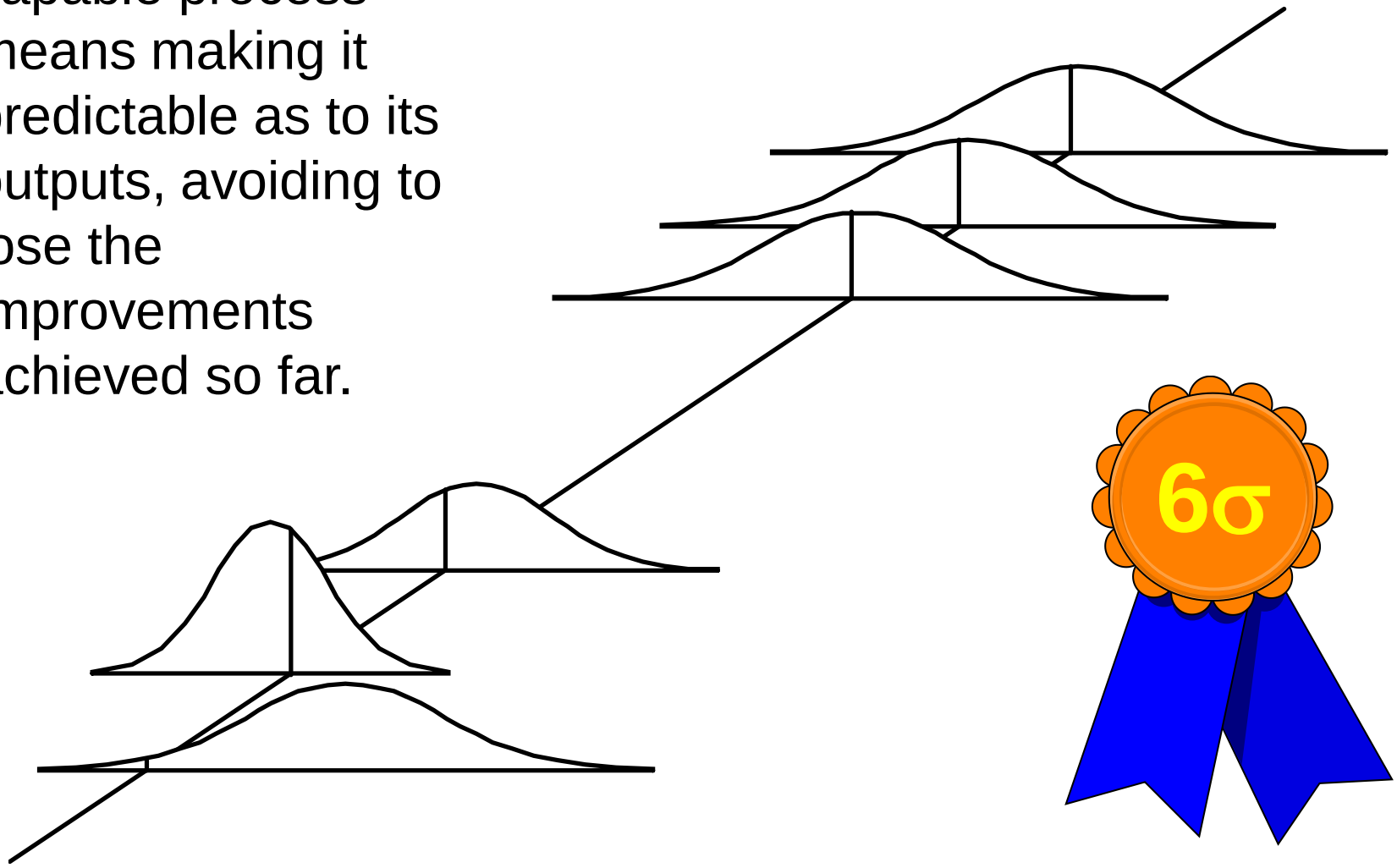
Predictable Process

However, when there are only common causes present, the process becomes predictable in terms of performance and it is easy to determine its future behavior.



Process Control

Controlling a capable process means making it predictable as to its outputs, avoiding to lose the improvements achieved so far.



Benefits of CEP

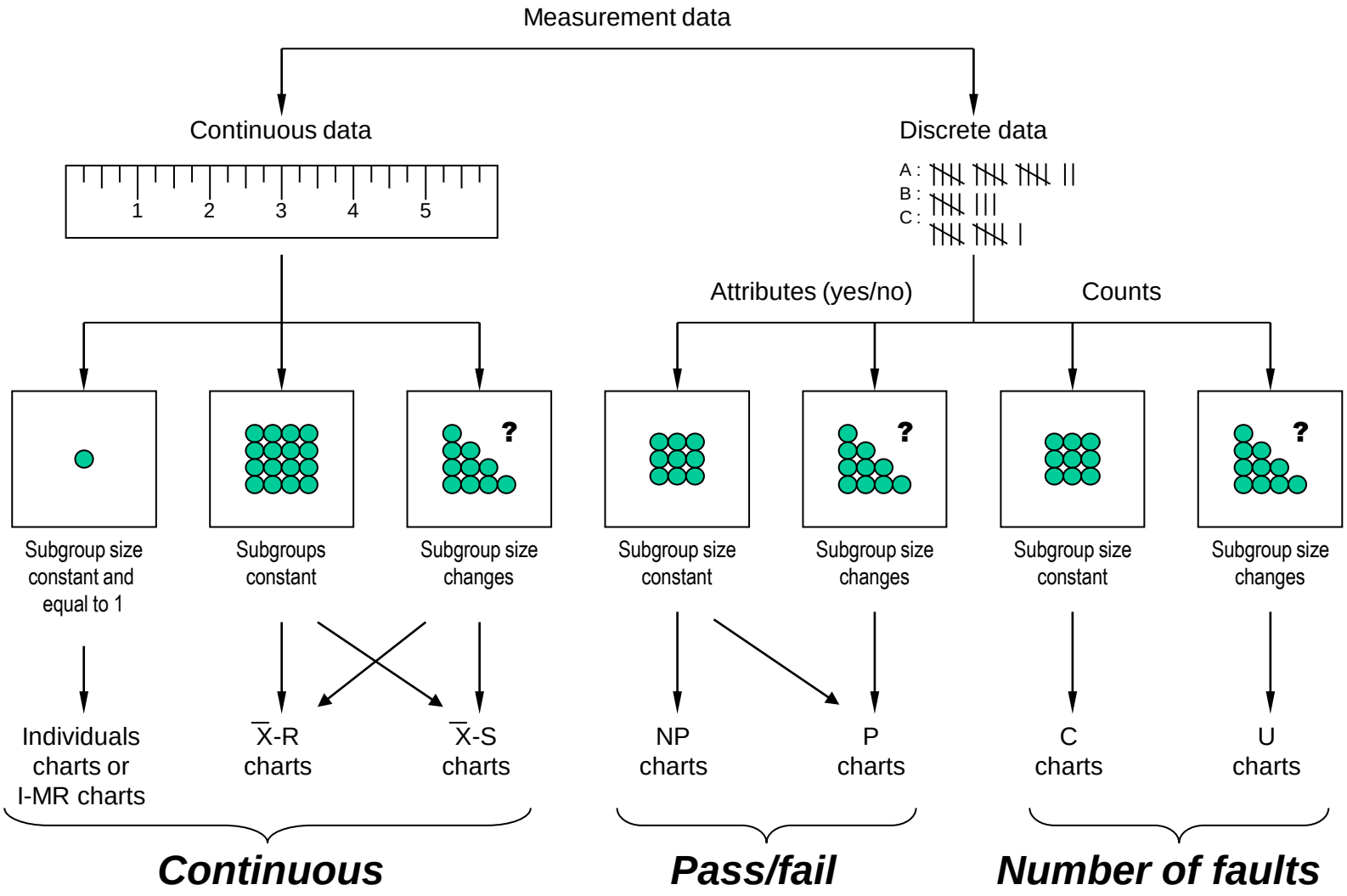
- Lower manufacturing Costs
- Correct working standards
- Predictable performance processes
- Realistic specifications
- Fewer inspections
- Shorter cycle time
- Better product quality

Supercontrol X Out of control

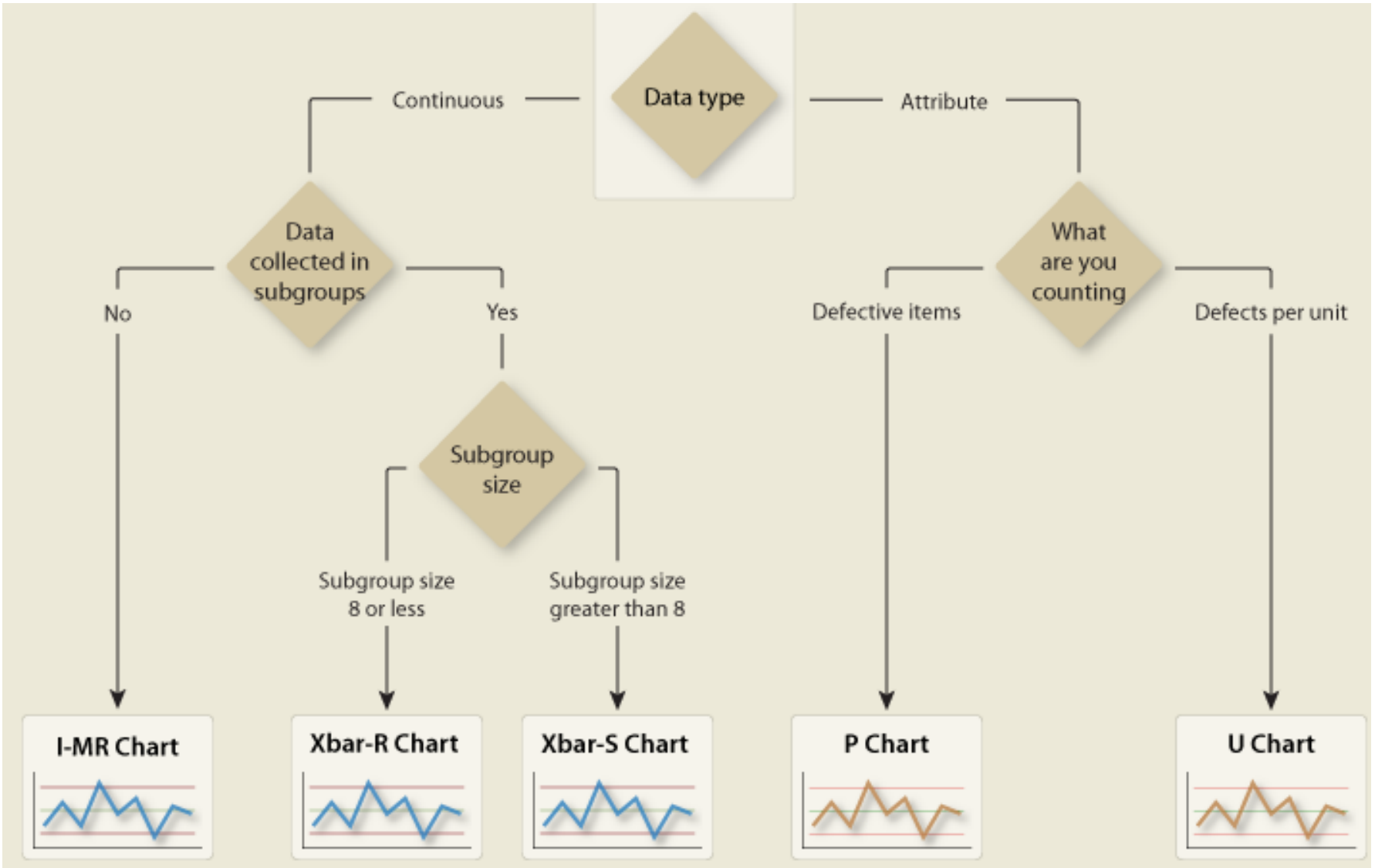
Two Types of Process Control Problems

	REALITY	
DECISION	Capable Process is Stable	Capable Process is not Stable
No adjustment	Ok	Out of Control
Adjustment	Supercontrol	Ok

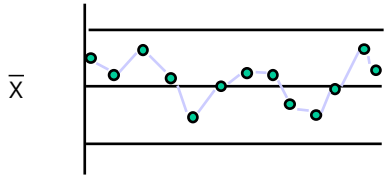
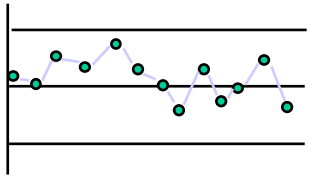
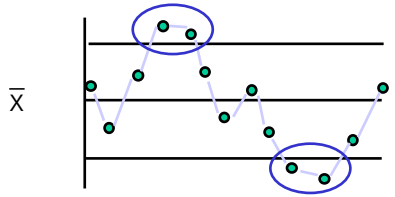
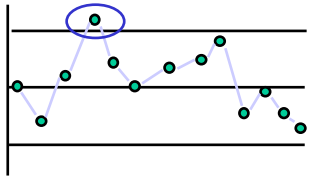
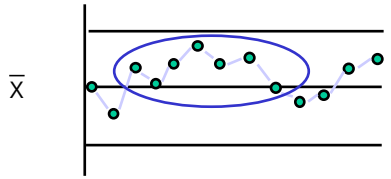
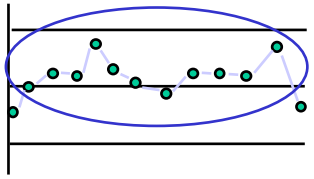
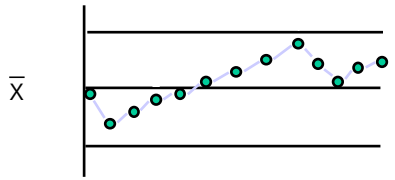
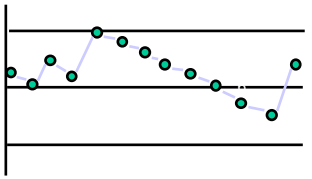
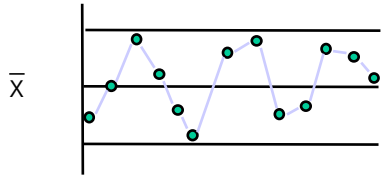
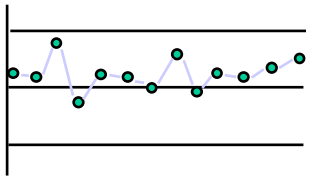
Control Chart types



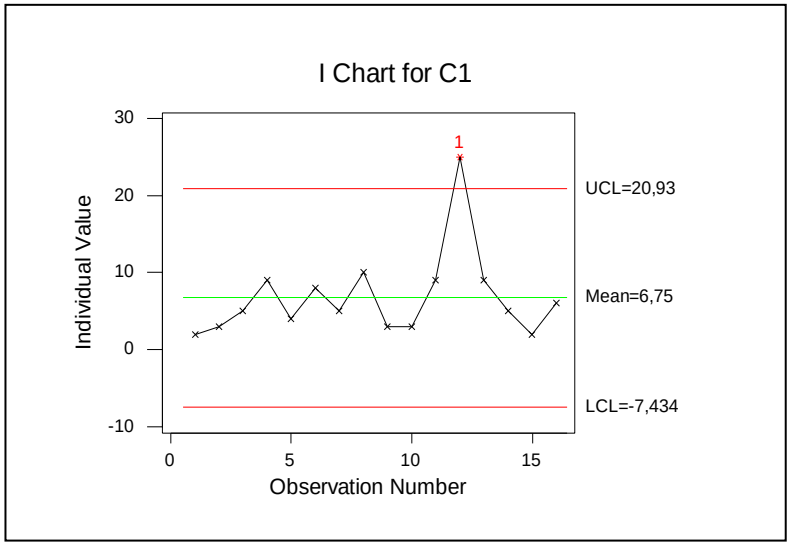
Control Chart types - Minitab



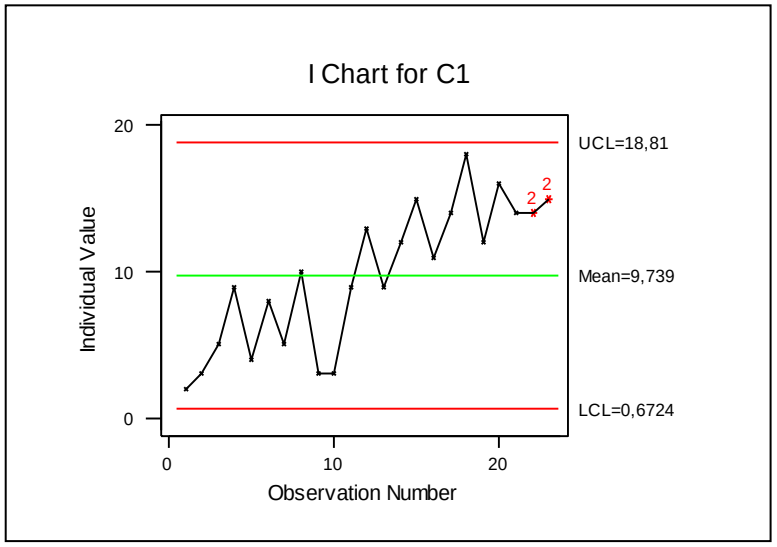
Control Chart Rules

Process In Control	Chart points do not form a particular pattern AND lie within the upper and lower chart limits.			The process is stable, not changing. Doesn't necessarily mean to leave the process alone. May be opportunities to improve the process and enjoy substantial benefits.
Process Out of Control	Chart points form a particular pattern OR one or more points lie beyond the upper or lower chart limits.			Alerts you that the process is changing. Doesn't mean you need to take corrective action. May be related to a change you have made. Be sure to identify the reason(s) before taking any constructive action(s).
Run	Chart points are on one side of the center line. The # of points in a run is called the length of the run.			Suggests the process has undergone a permanent change (+ or -) and is now becoming stable. Often requires that you recompute the control lines for future interpretation efforts.
Trend	A continued rise or fall in a series of points (7 or more consecutive points in the same direction).			Often seen after some change has been made. Helps tell you if the change(s) had a + or - effect. May also be part of a learning curve associated with some form of training.
Cycle	Chart points show the same pattern changes (e.g., rise or fall) over equal periods of time.			Often relates to factors that influence the process in a predictable manner. Factors occur over a set time period and have +/- effect. Helps determine future work load/staffing levels.

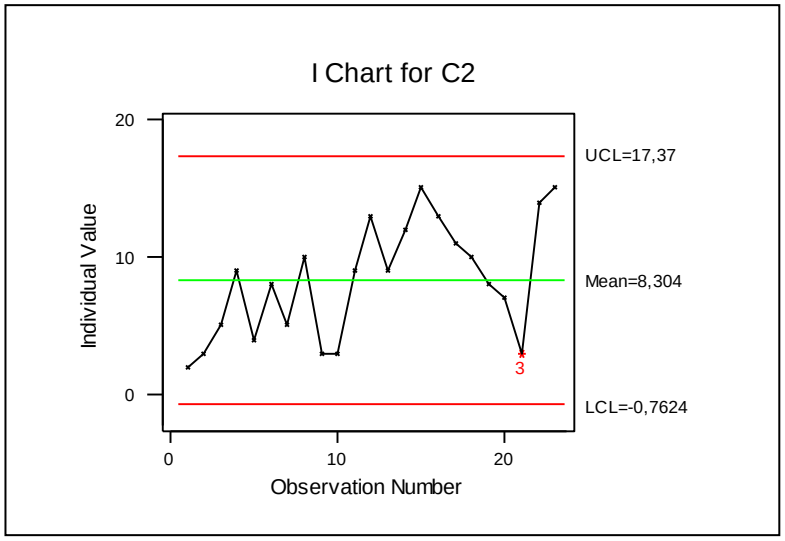
Control Chart Rules



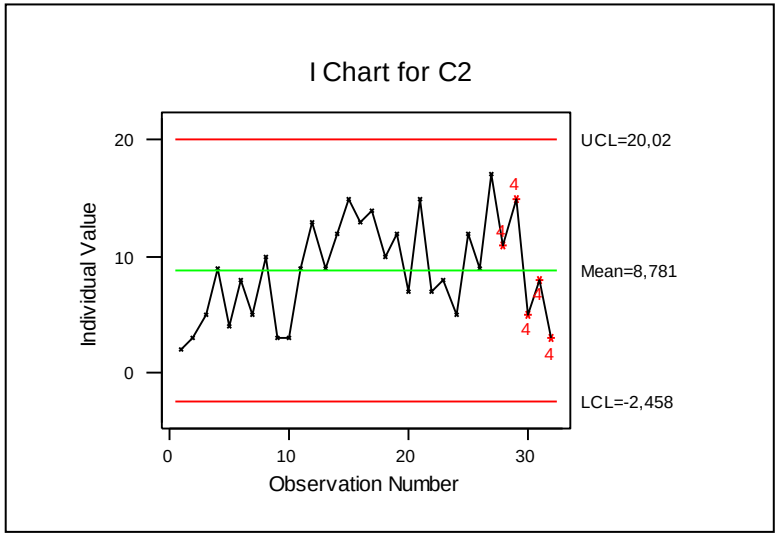
One point outside the UCL or LCL



Nine points in a row on same side of center line

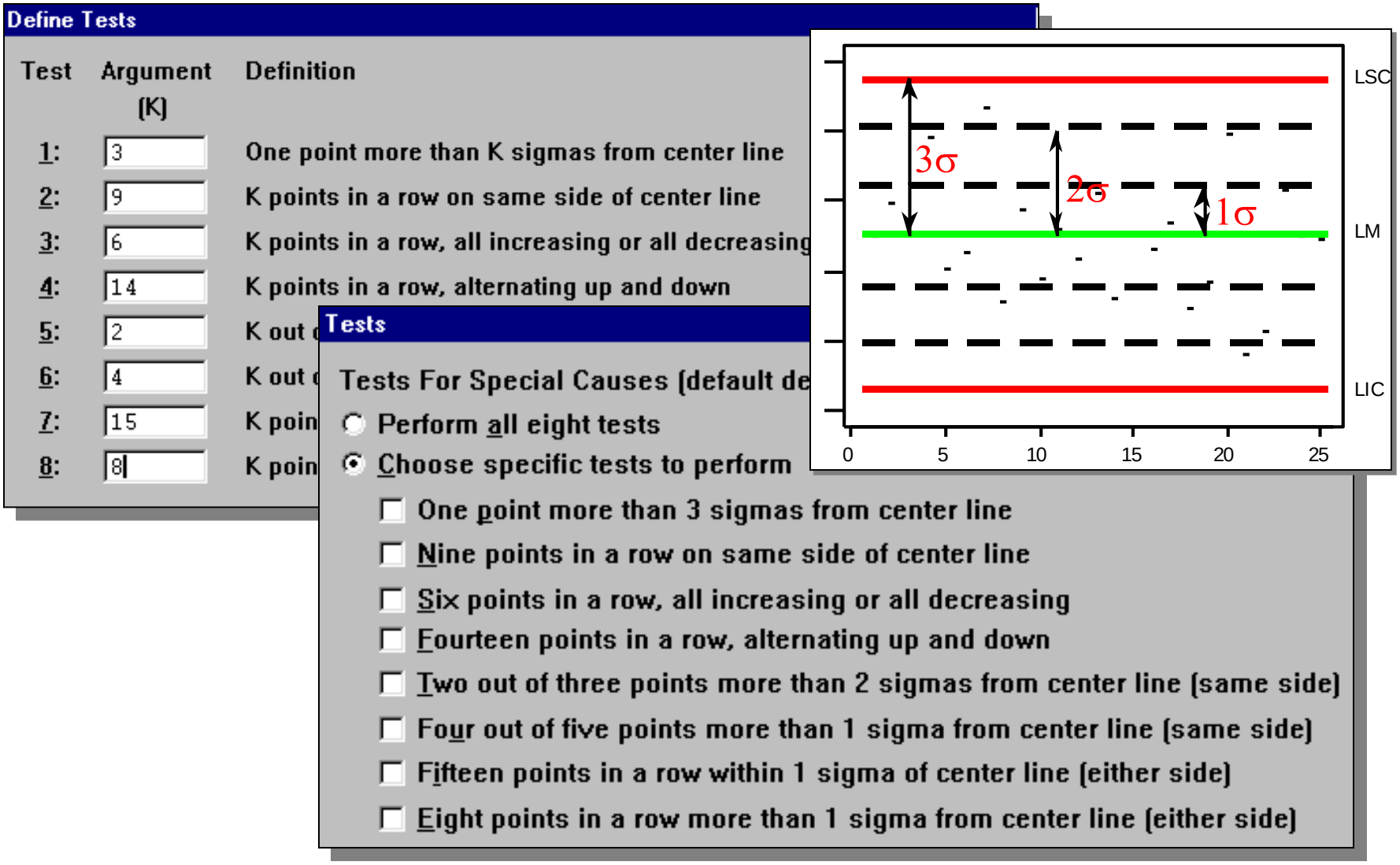


Six points in a row, all increasing or decreasing



Fourteen points in a row, alternating up and down

Runs Tests


Define Tests
Test
Argument (K)
Definition
1: 3 One point more than K sigmas from center line
2: 9 K points in a row on same side of center line
3: 6 K points in a row, all increasing or all decreasing
4: 14 K points in a row, alternating up and down
5: 2
6: 4
7: 15
8: 8
Tests
Tests For Special Causes (default de
Perform all eight tests
Choose specific tests to perform
One point more than 3 sigmas from center line
Nine points in a row on same side of center line
Six points in a row, all increasing or all decreasing
Fourteen points in a row, alternating up and down
Two out of three points more than 2 sigmas from center line (same side)
Four out of five points more than 1 sigma from center line (same side)
Fifteen points in a row within 1 sigma of center line (either side)
Eight points in a row more than 1 sigma from center line (either side)
LSC
LM
LIC
3σ
2σ
1σ
0
5
10
15
20
25

Control x Specification

Control limits are for subgroup averages. Most specifications are for individual values.