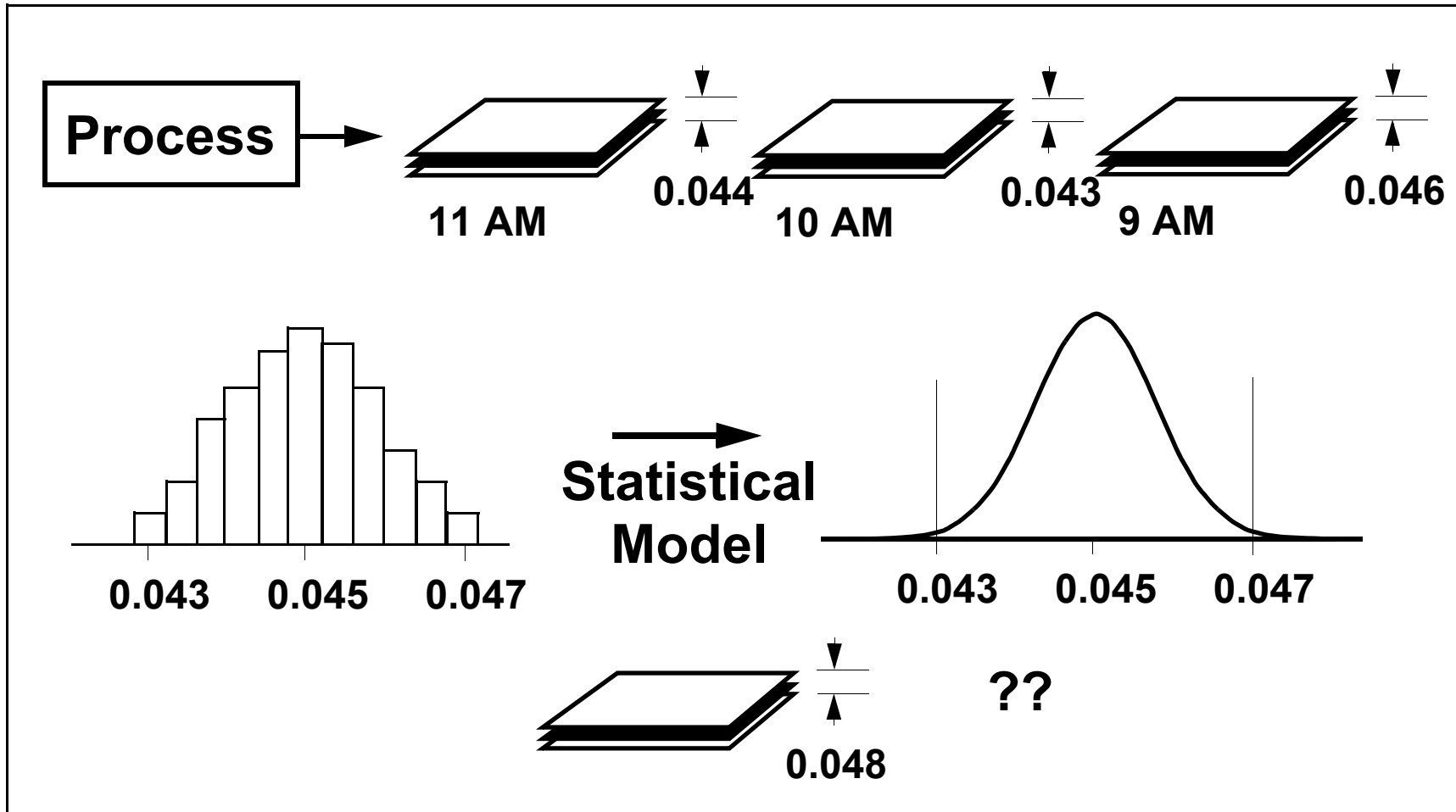


Lecture #14

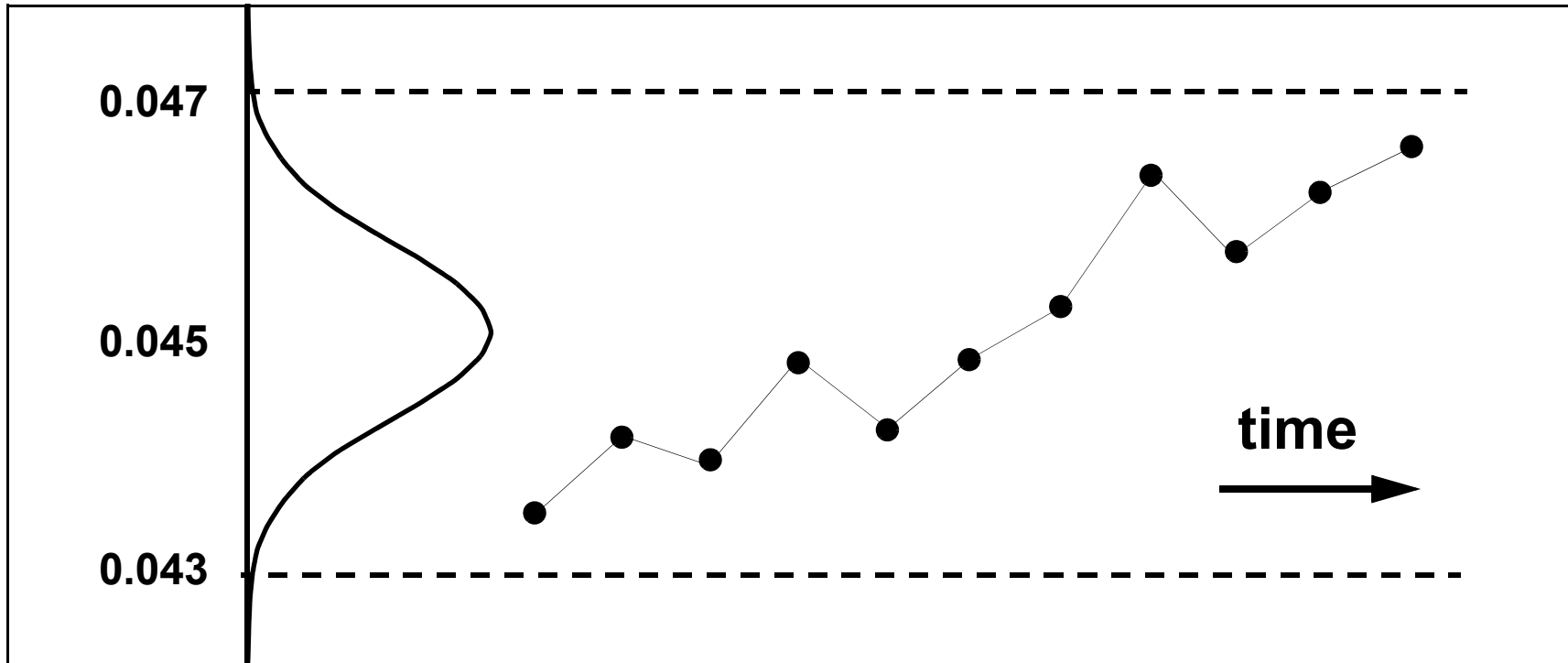
Prof. John W. Sutherland

Sept. 28, 2005

Process as a Statistical Distn.

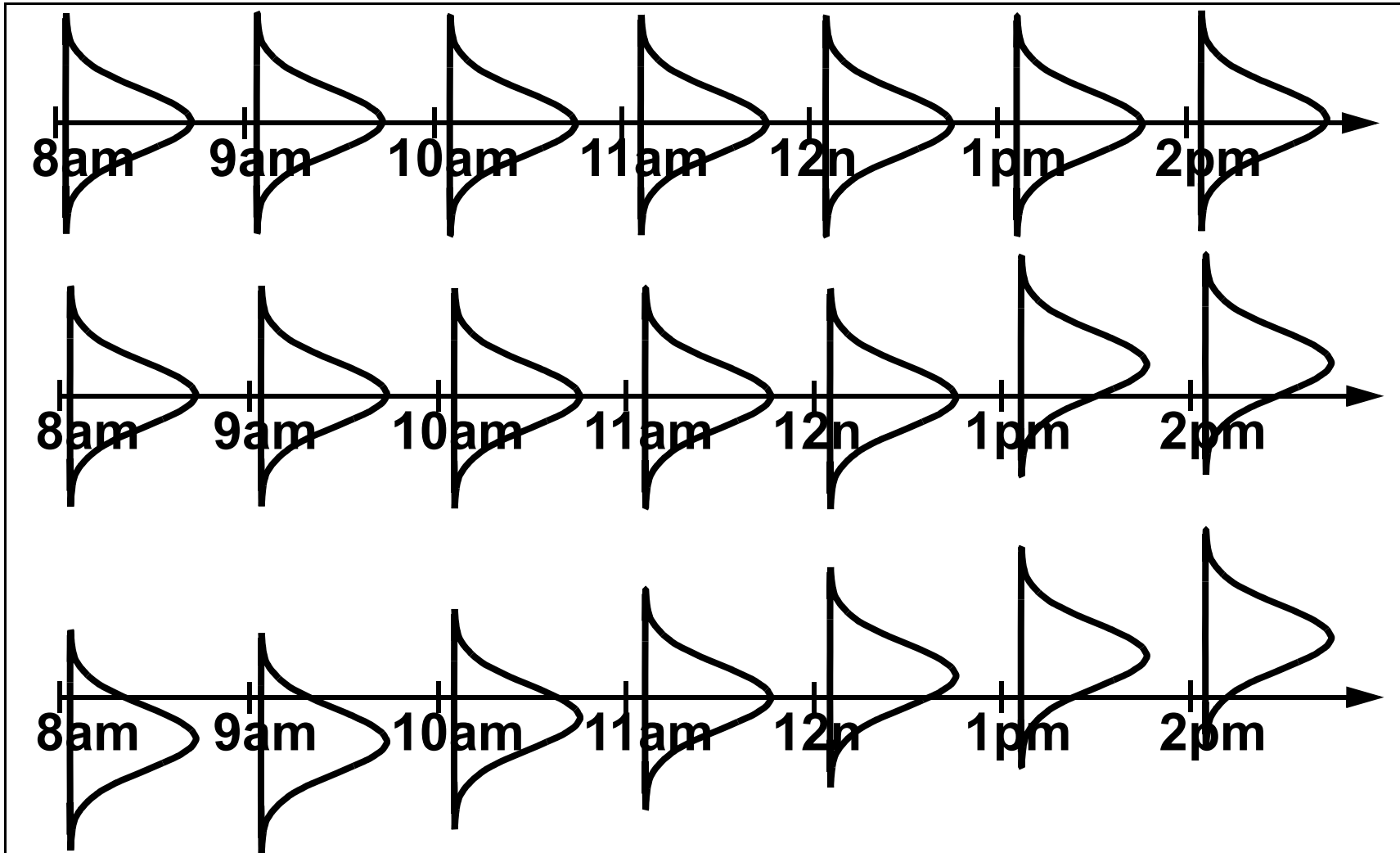


Process Behavior over Time



The behavior of the process as a function of time - this is a big piece of the puzzle

Changes in Process Behavior



Changes in Mean & Variability

Summary - Evolution of Process Behavior

- Data collected over time may be used to develop a statistical model for the process -- assumes process is subject to only common causes
- Process mean and variability may change over time -- indicates a lack of process stability, inconsistency, "out of control", not predictable
- Track process behavior (periodic sampling) -- detect changes in mean / variability

Shewhart's View of SPC

Shewhart's book - *Economic Control of Quality of Manufactured Product* (1931) - preface establishes the principles of SPC

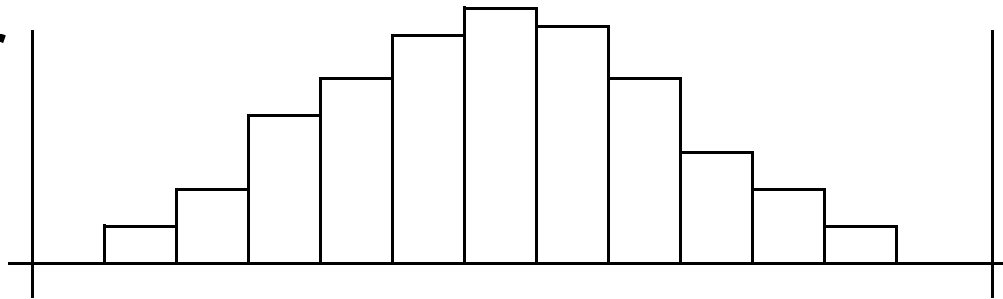
1. Fundamental focus is on the process: "ways and means of satisfying human wants."
2. Overarching objective - economic process operation: "Reduce everything possible to routines requiring a minimum amount of effort."

3. **Normal process operation - behavior w/in predictable limits: "It has been found possible to set up limits within which the results of routine efforts must lie if they are to be economical."**
4. **Deviations outside the limits signal presence of problems that are jeopardizing economic success: "Deviations in the results of a routine process outside such limits indicate that the routine has broken down and will no longer be economical."**
5. **Deviations outside the limits - find root cause of the trouble in the process and remove it: "The routine has broken down and will no longer be economical until the cause of trouble is removed."**

Comments

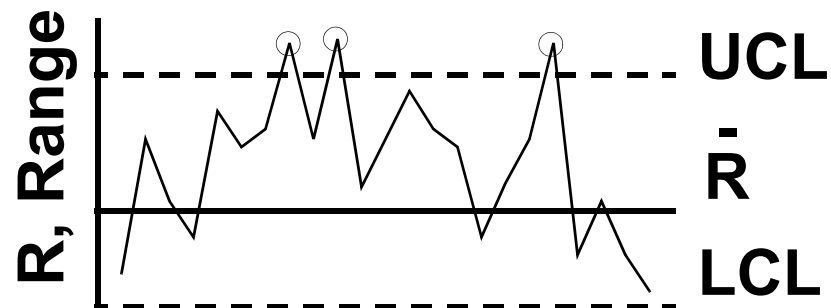
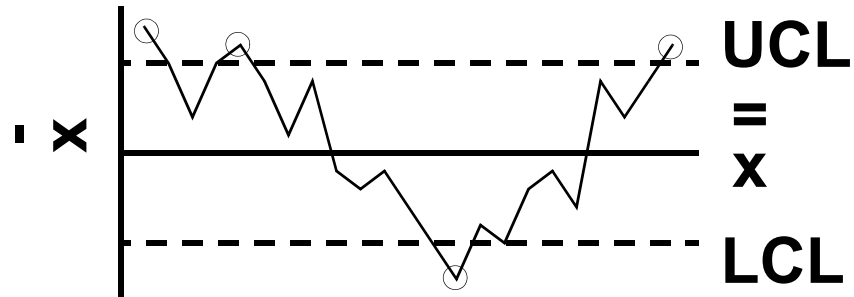
- No mention of the product or conformance of the product to specifications.
- A controlled process is one where, based on experience, we can predict (within limits) future behavior.
- Special causes are sources of waste/inefficiency
- When a process is not in control (i.e., special causes present), it is no longer operating routinely/predictably, economic success is jeopardized.

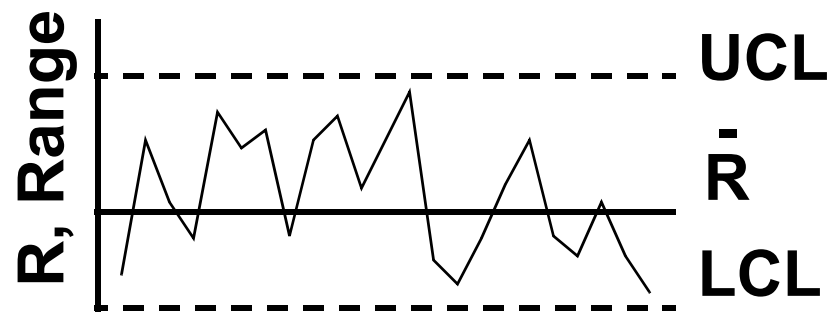
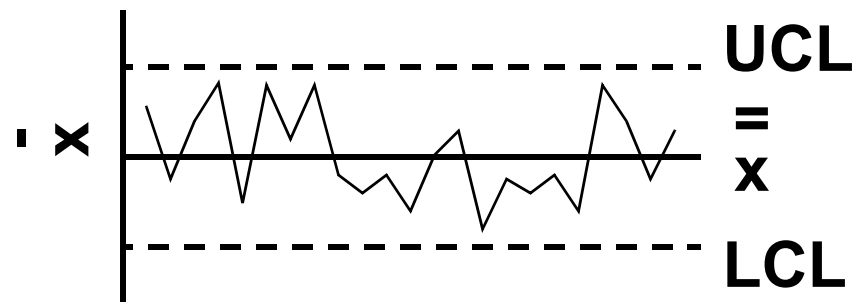
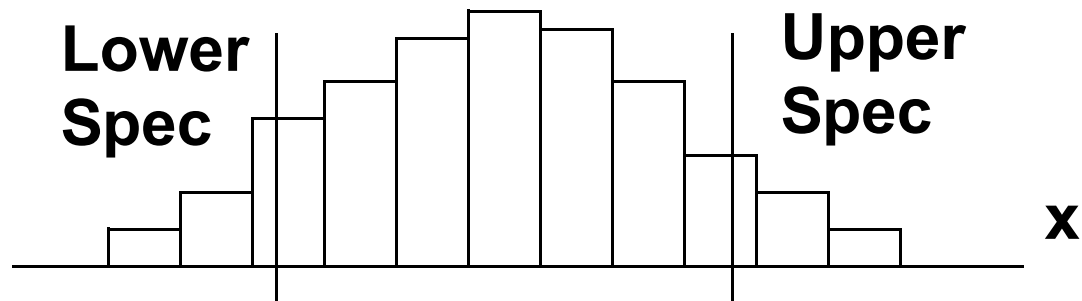
Lower
Spec



Upper
Spec

\bar{x}



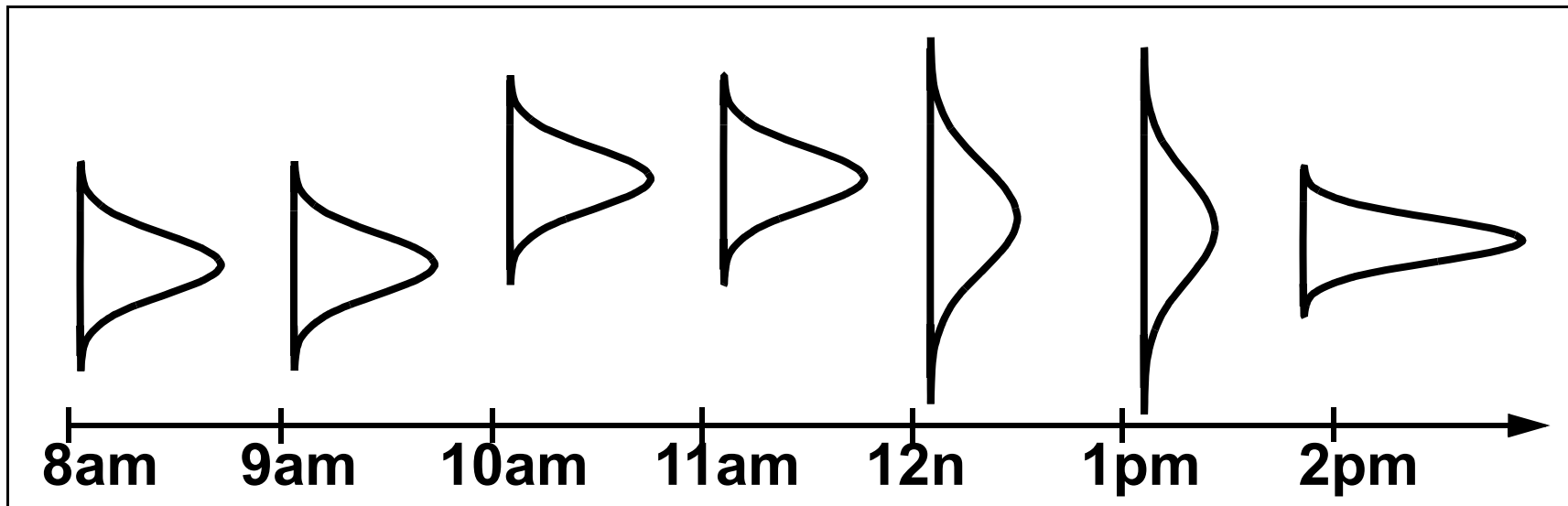


Remember

- Only individual measurements may be compared to engineering specifications.
- Specs tell us about whether customer expectations are being met.
- Control charts tell us about process consistency, stability, or predictability. The presence of special causes means that our process is no longer consistent, stable, predictable, economical.

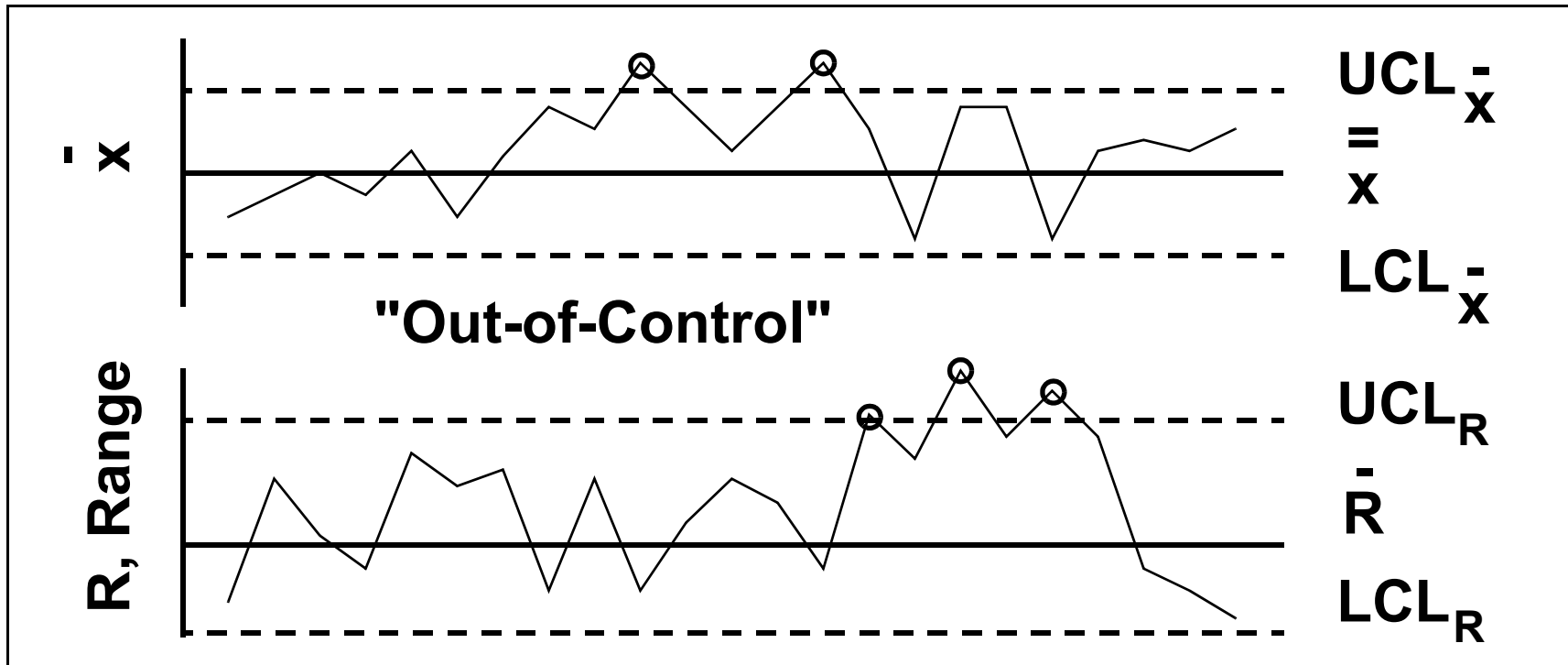
Var. Mgmt. w/ Control Charts

How to Detect Special Causes??



Since both mean and variability may be changing over time, need to collect samples & do calculations that tell us about centering (\bar{X}) and spread (R)

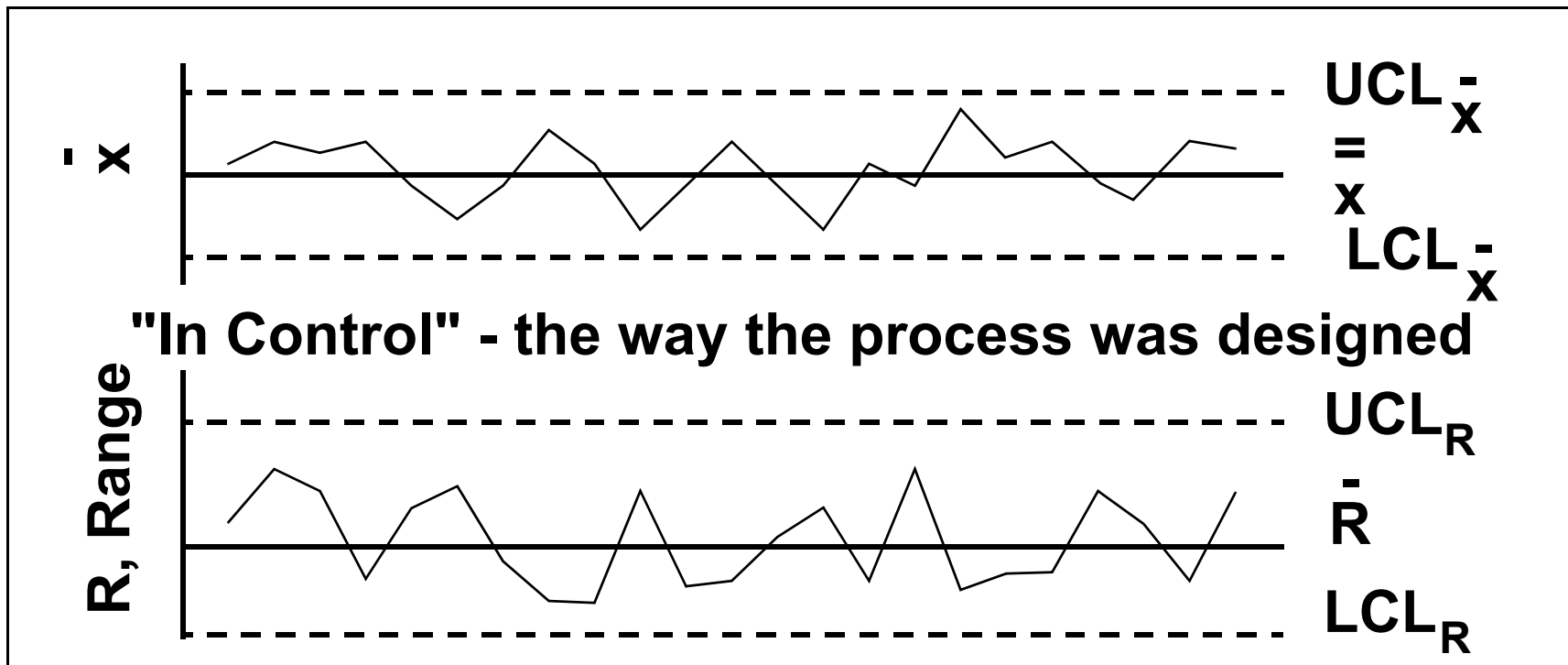
Detecting Special Causes



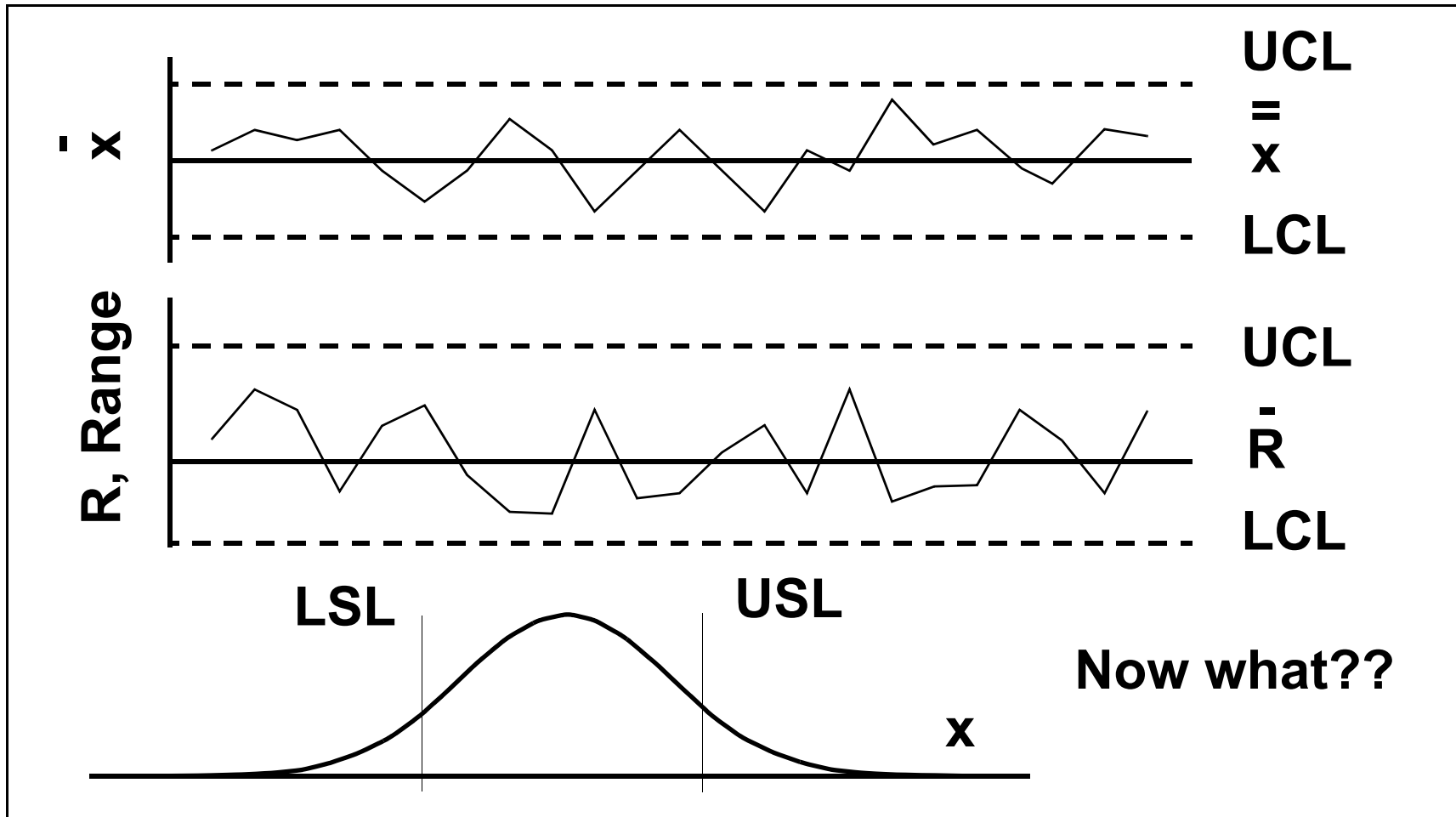
Circle the points that are "statistical signals" - special causes are present - process not routine / economical

Achieving Control

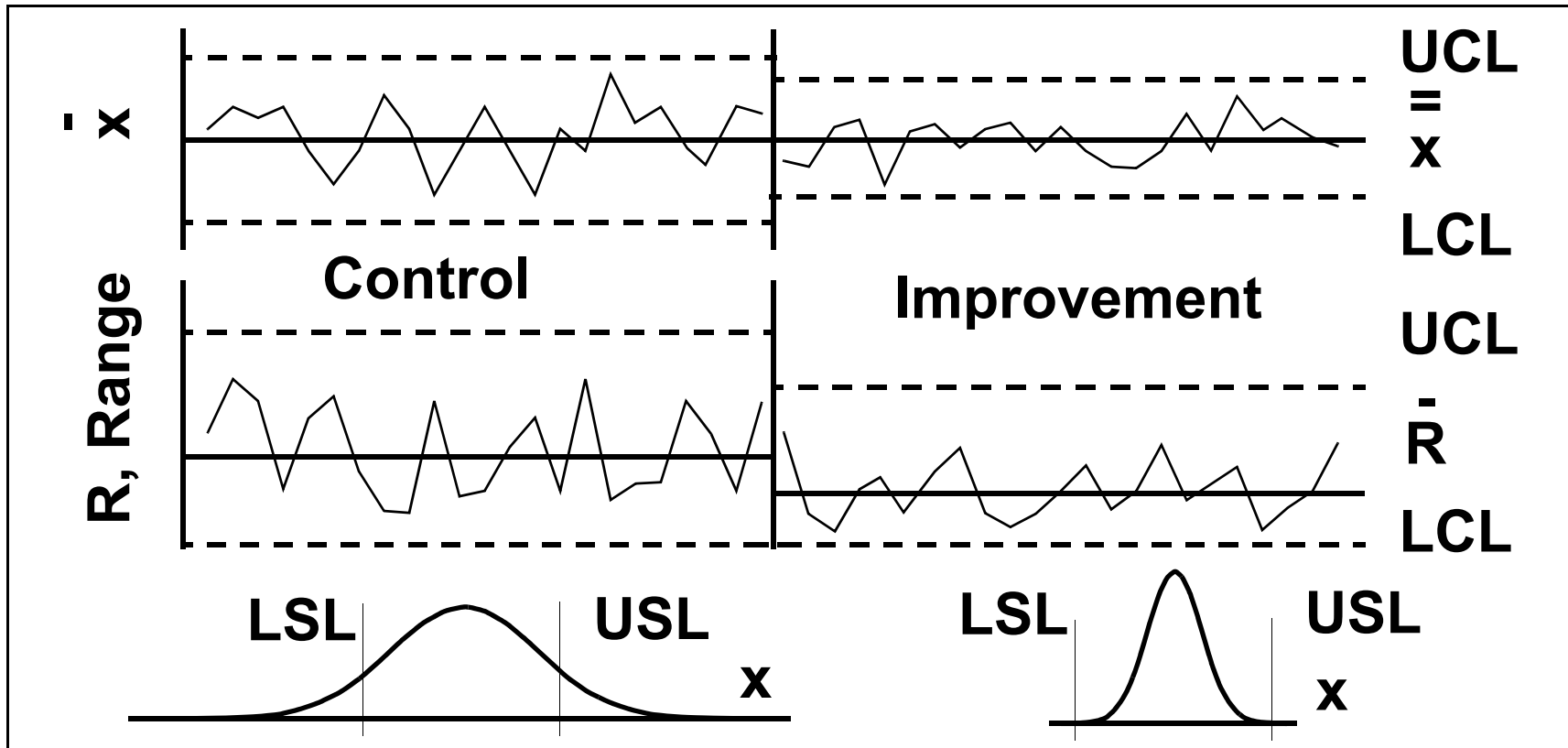
Let's assume we take actions that eliminate the local faults manifested in the previous charts.



Control - is it enough??

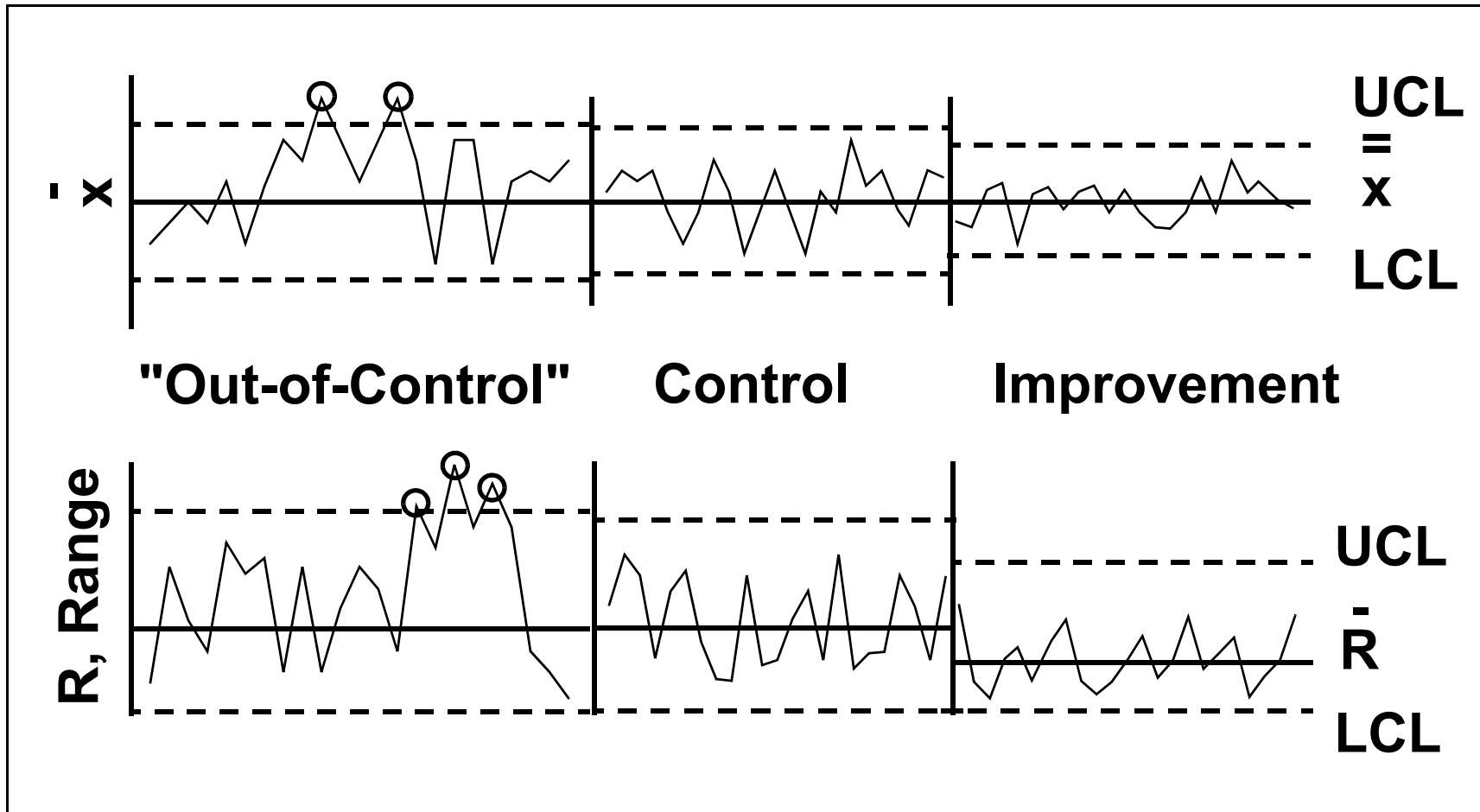


Improvement



Identify & eliminate common causes / system faults

Summary

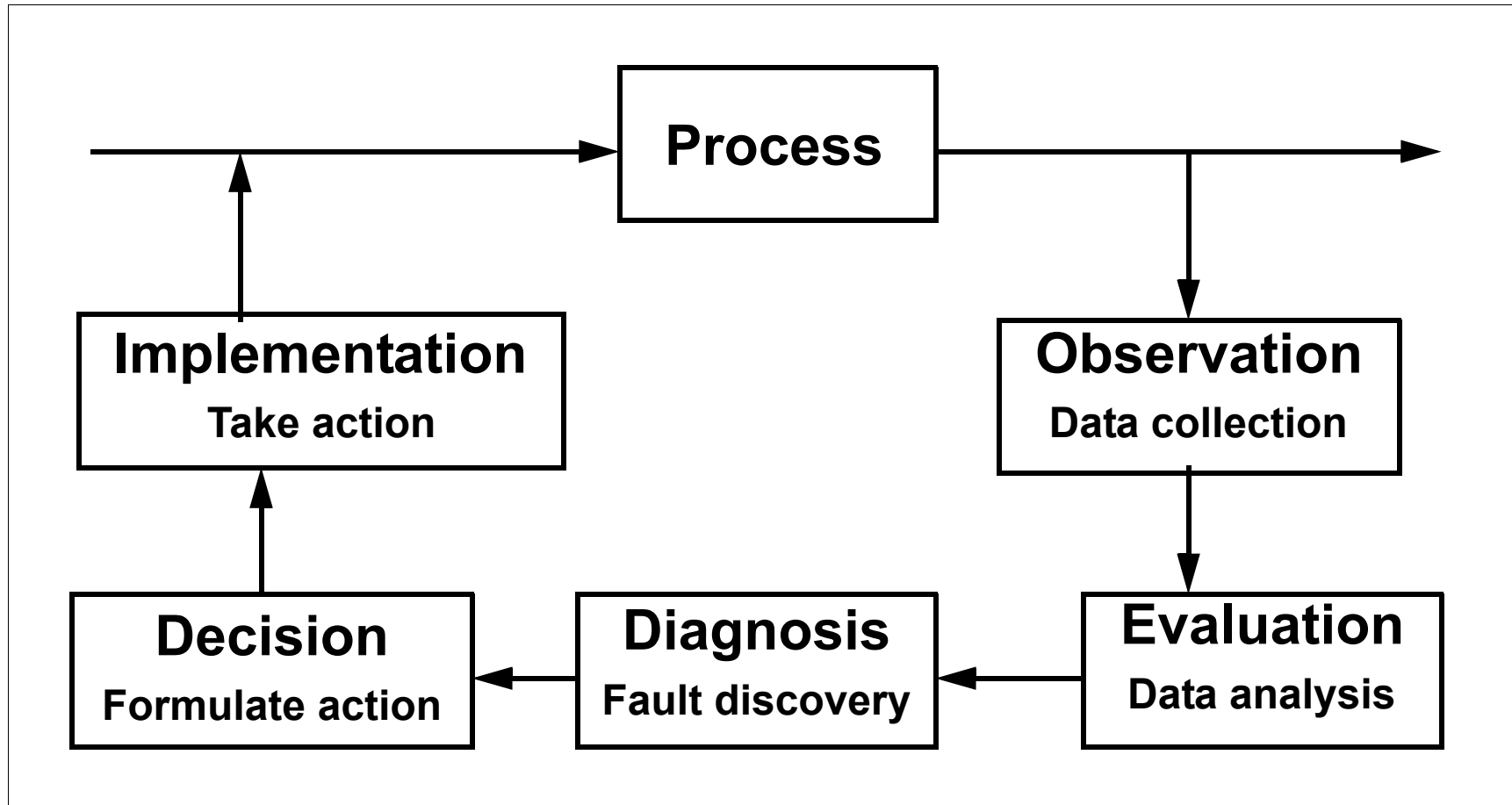


Process of Statistical Process Control

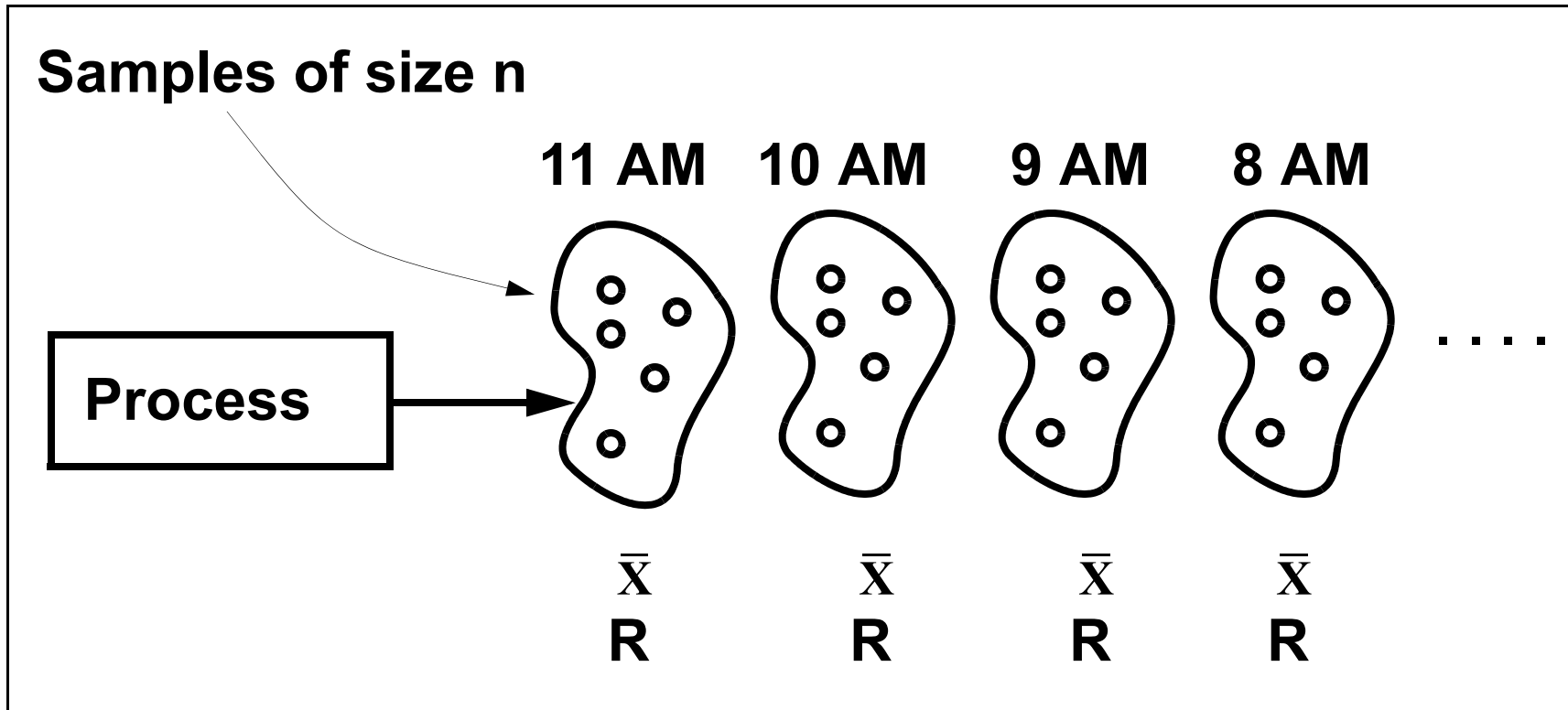
Uses of Control Charts

- **Off-line.** To identify when special/sporadic causes enter the process and to characterize the level of common-cause variability. Where to look for improvement opportunities. Help to formulate & assess effect of actions.
- **On-line.** To serve as a tool (provide a sound economic basis) for operators to make decisions at the machine as to when to adjust the machine (and when to leave it alone).

Control System View of SPC

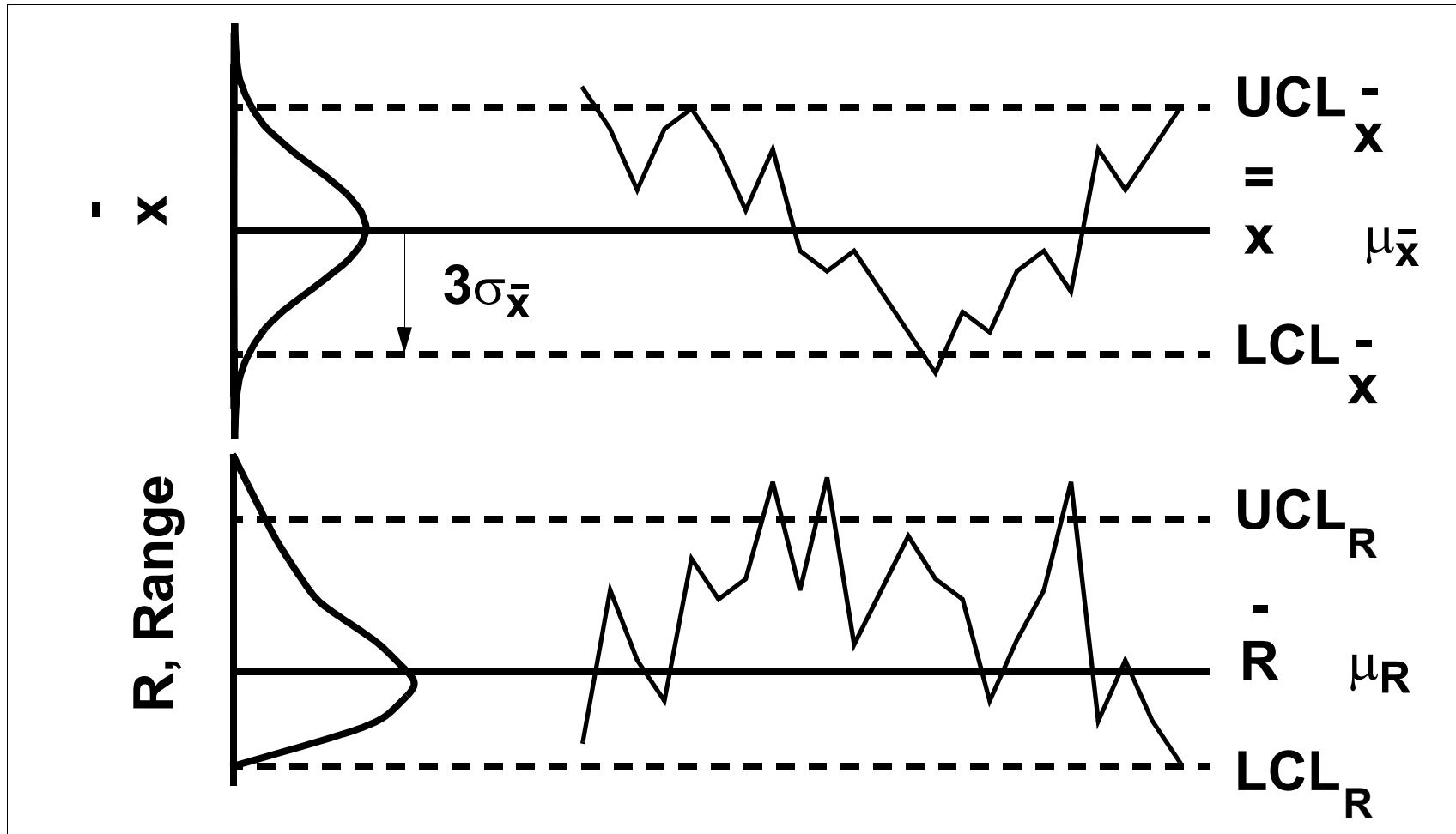


So, where do we stand??

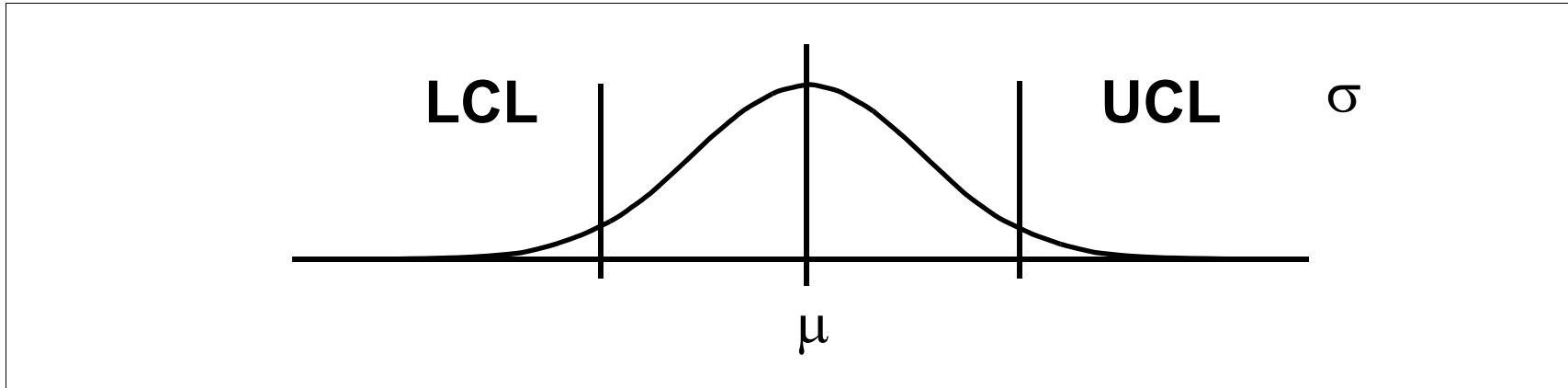


Monitor changes in \bar{X} and R as a function of time

Shewhart Control Chart Model

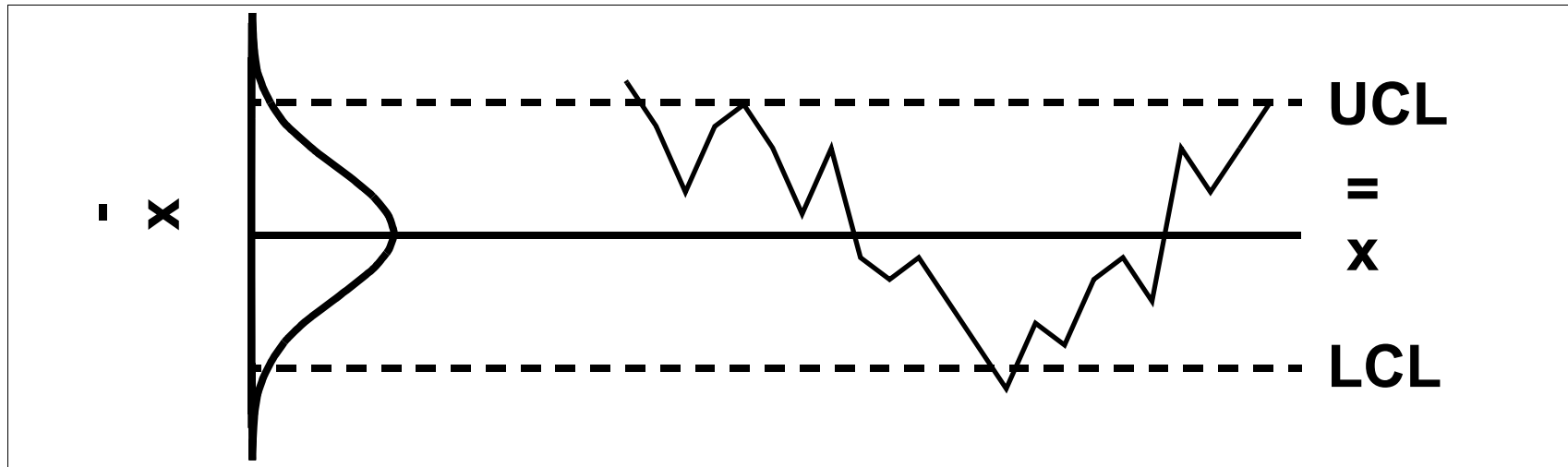


Control Chart - Hypothesis Test



Control limits depend, of course, on the risk level, α

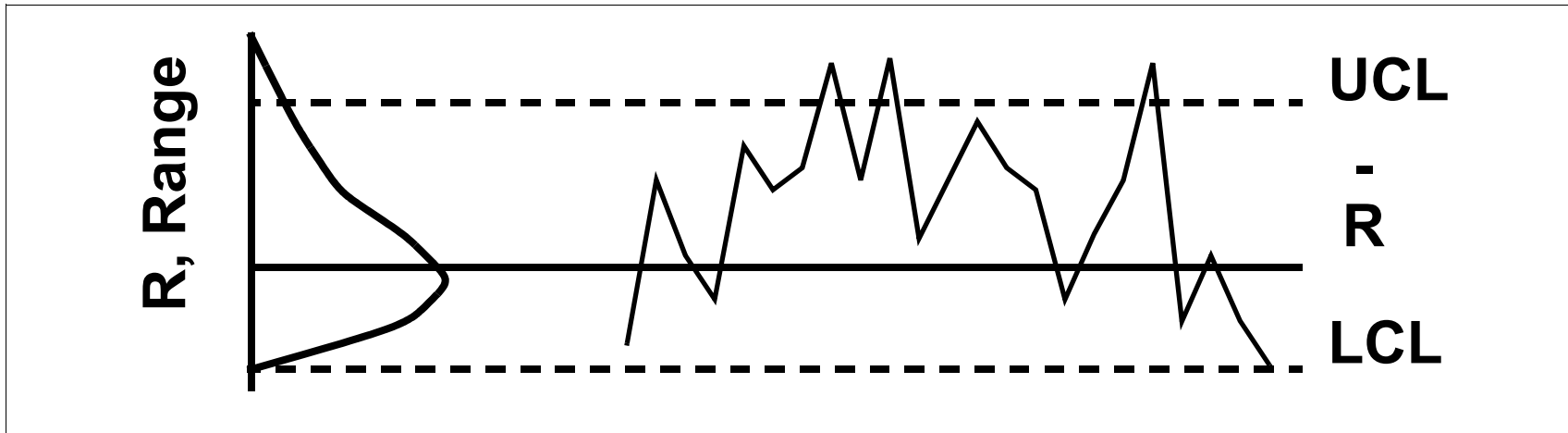
Where do we put the limits??



Centerline

Put the limits 3 standard deviations from the mean

Limits??



Centerline

Put the limits 3 standard deviations from the mean