Lecture #14

ERDM

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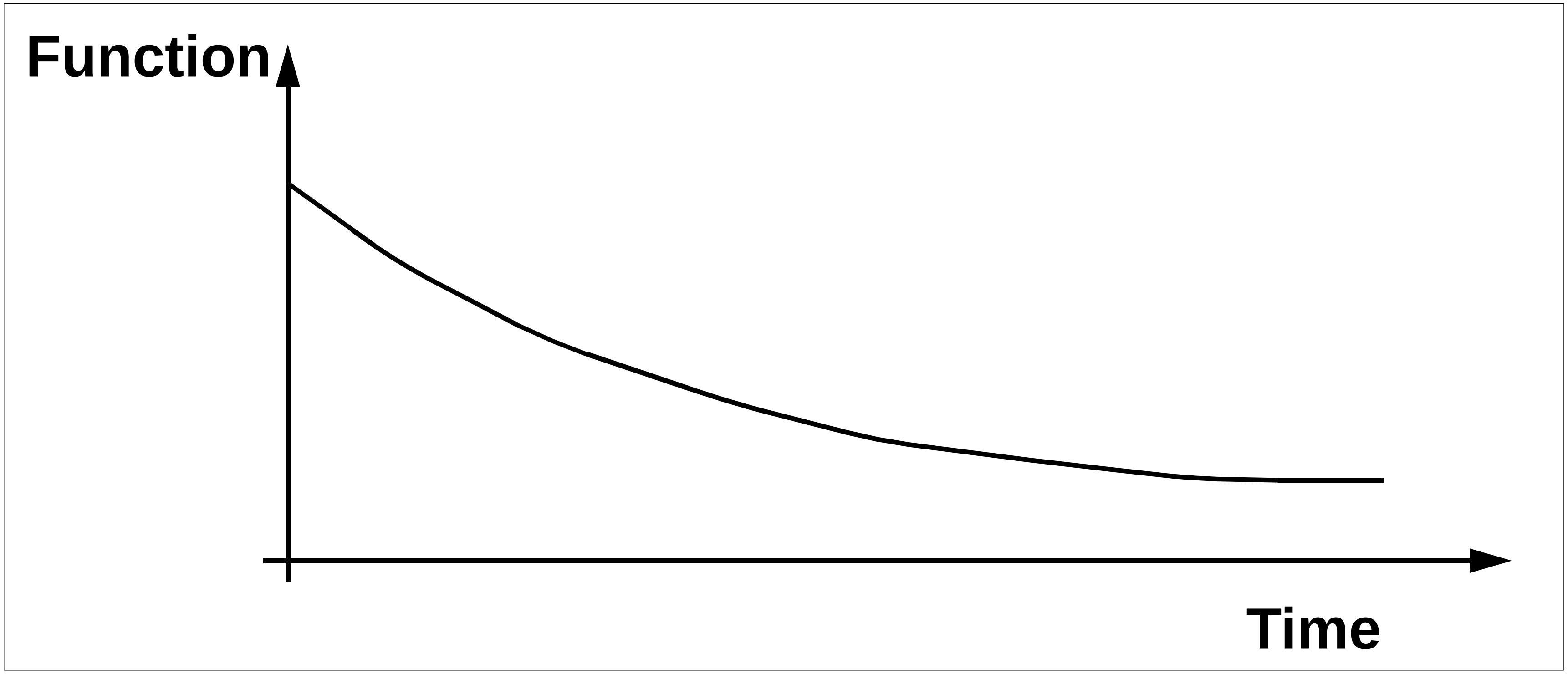
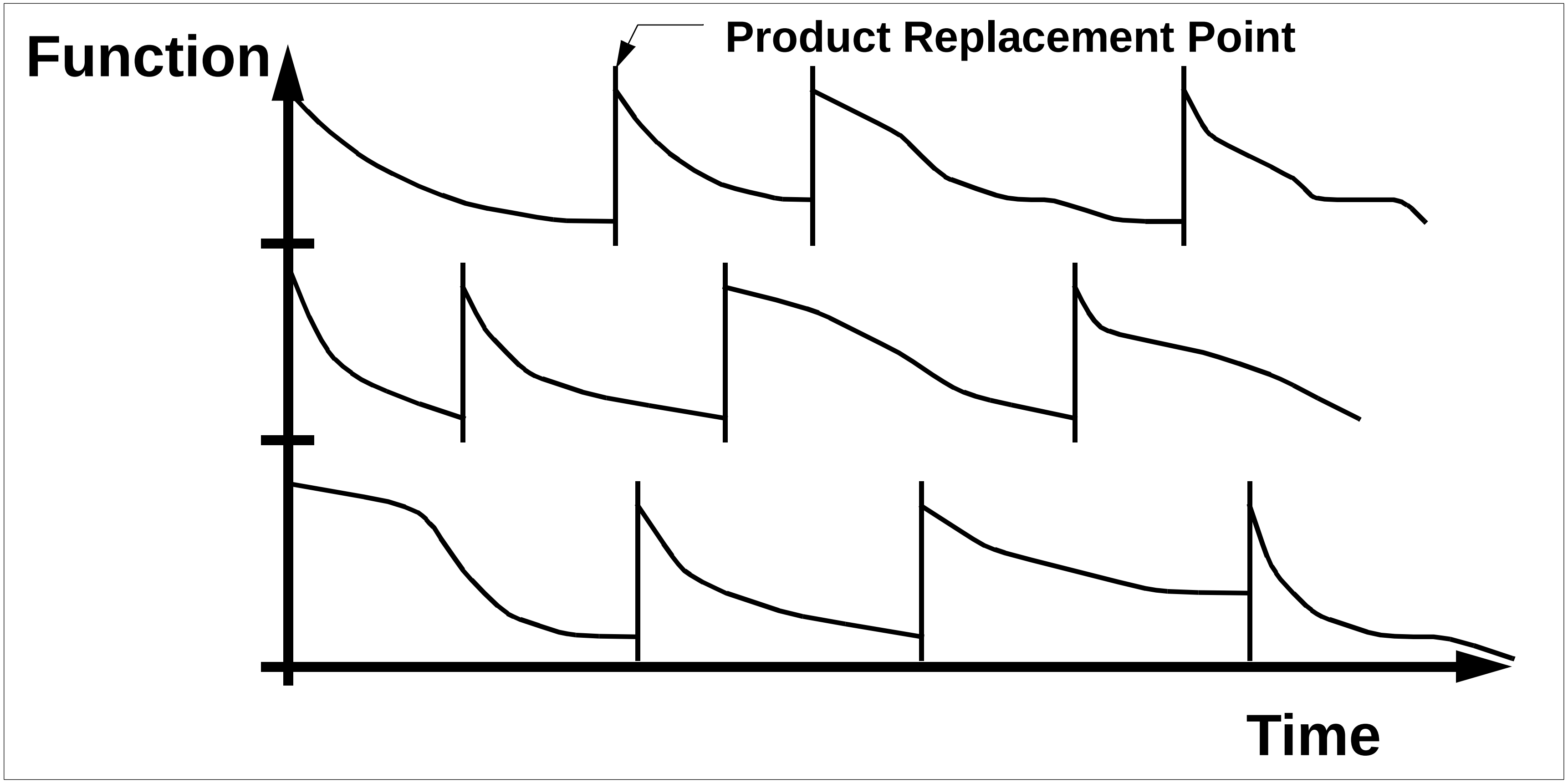
Product Function



We observe that prod. function deteriorates over time.

Product Function



Multiple products - multiple use cycles -- how to handle?

Background

In defining the course syllabus, several areas immediately evident:

- **Design**
- **Manufacturing**
- **Life Cycle Issues**

Several topics important (building blocks) but not covered elsewhere:

- **<u>Statistical issues</u>**
- **Multi-criteria decision-making**
- **Optimization**

Objective

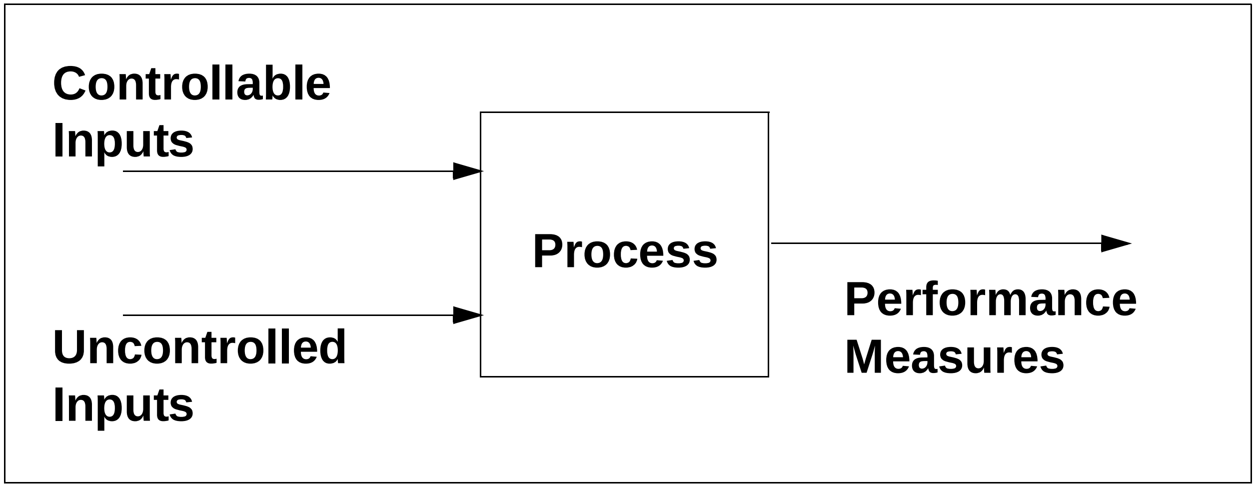
Introduce basic concepts related to the orgin, treatment, and characterization of variation.

- **Origin and types of variation**
- **Quality (SPC & DOE)**
- **Reliability**

A future class will tie many of these topics to “the environment”

Introduction

- **Consider block diagram for a manufacturing process**



- **Performance measures (outputs) from the process may include: Part dimensions, surface finish, machine power, tool life, shrinkage, etc.**

Introduction (cont.)

We often evaluate the success of the process by comparing these measures to desired values.

- The controllable inputs are variables that we suspect have a strong influence on performance. These include: cutting conditions, tooling, barrel temperature, operator actions, etc.

- The uncontrollable inputs are often assumed to have little or no effect on performance. Examples are: vendors, machine maintenance, material inhomogeneities, etc.

Degree-of-Control

- **Process inputs: either controllable or uncontrollable.**

- **Distinction is restrictive - most input variables fall somewhere in between. Machine settings (controlled variables) vary from their nominal values and are thus somewhat uncontrollable.**

- **Often variables could be controlled if we wished to.**

- **The amount of control (degree-of-control) we wish to exercise is an economic decision - increased control carries with it an economic price tag.**

Variation

The block diagram structure shown previously can be used to describe either process or product performance. Focus, for now, on process behavior.

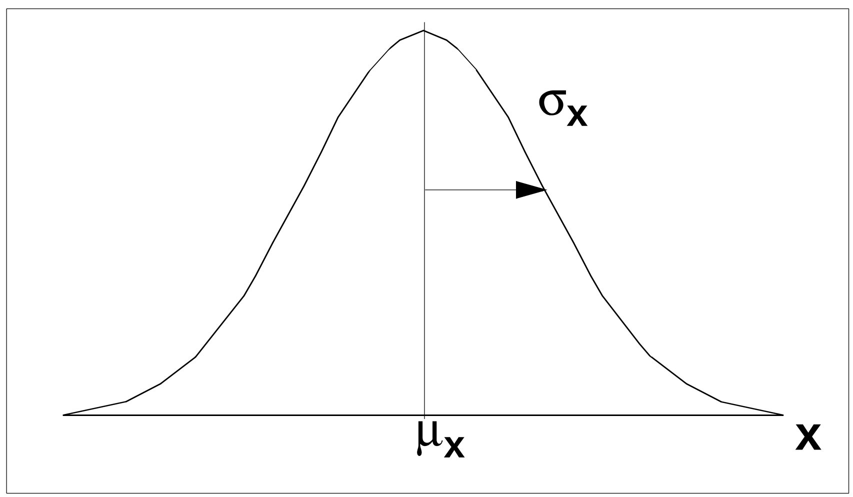
When variables are not controlled, they change or vary. Variations in process inputs produce variations in the process output.

Thus, uncontrolled process inputs produce manufacturing variation.

Manufacturing Variation

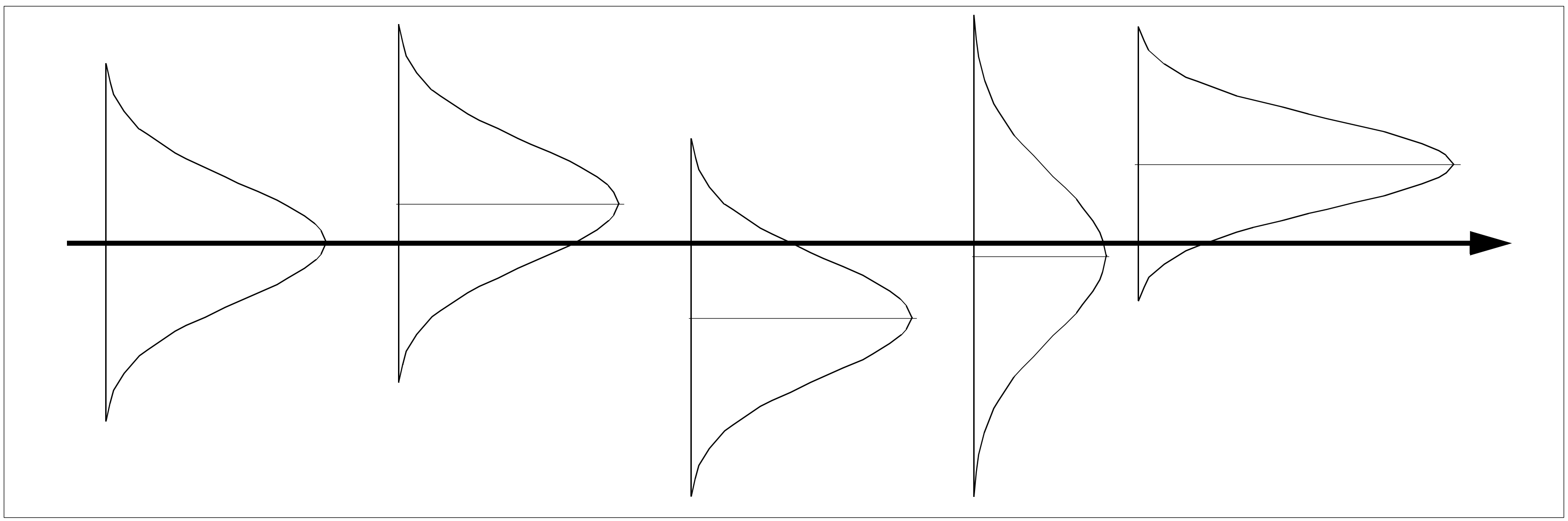
Broken down into two categories:

- **Common causes (Deming): sources of variation that influence every product. Define the system (system faults). Chronic problems (Juran). Mgmt. responsible**

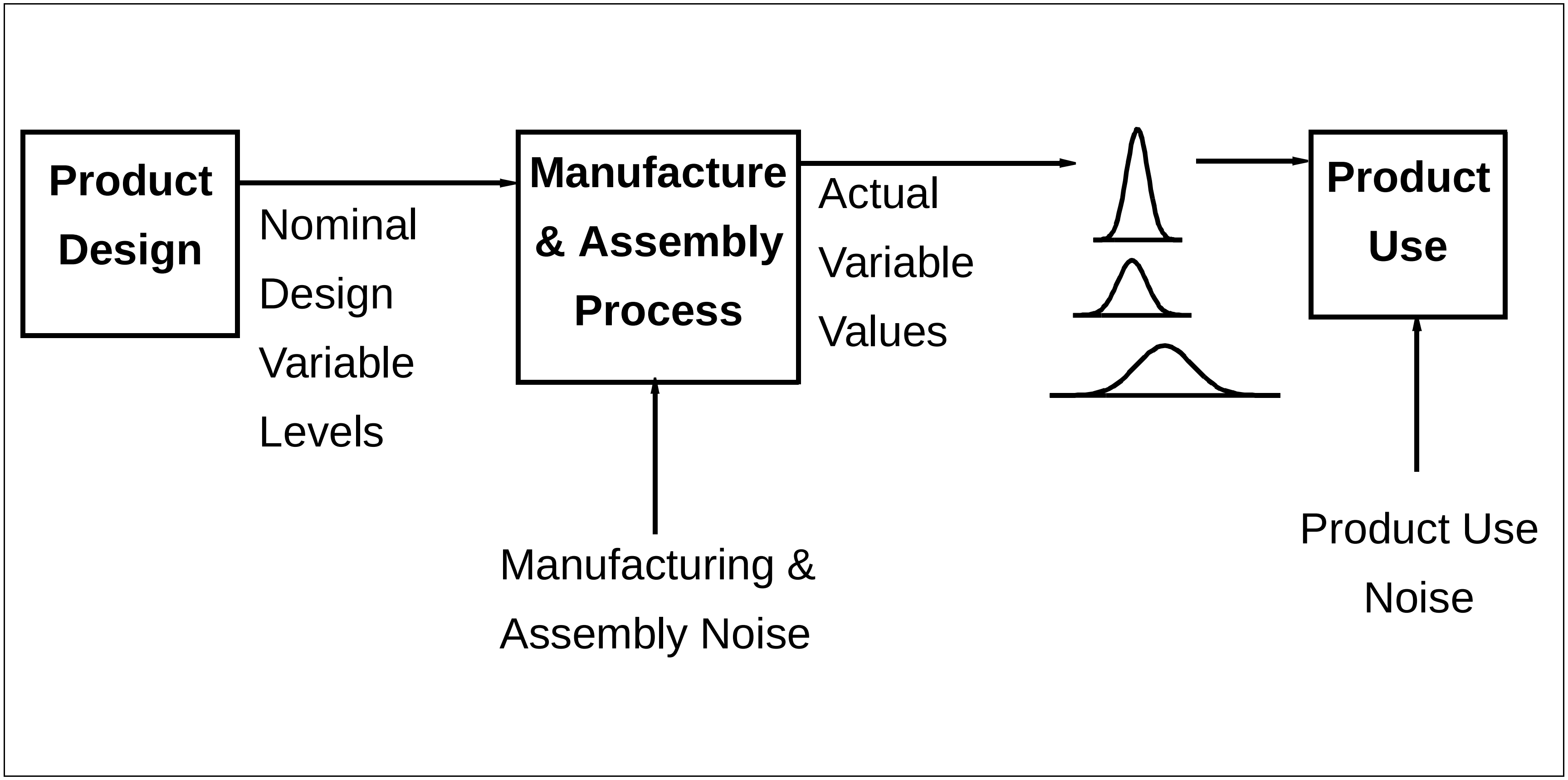


Manufacturing Variation (cont.)

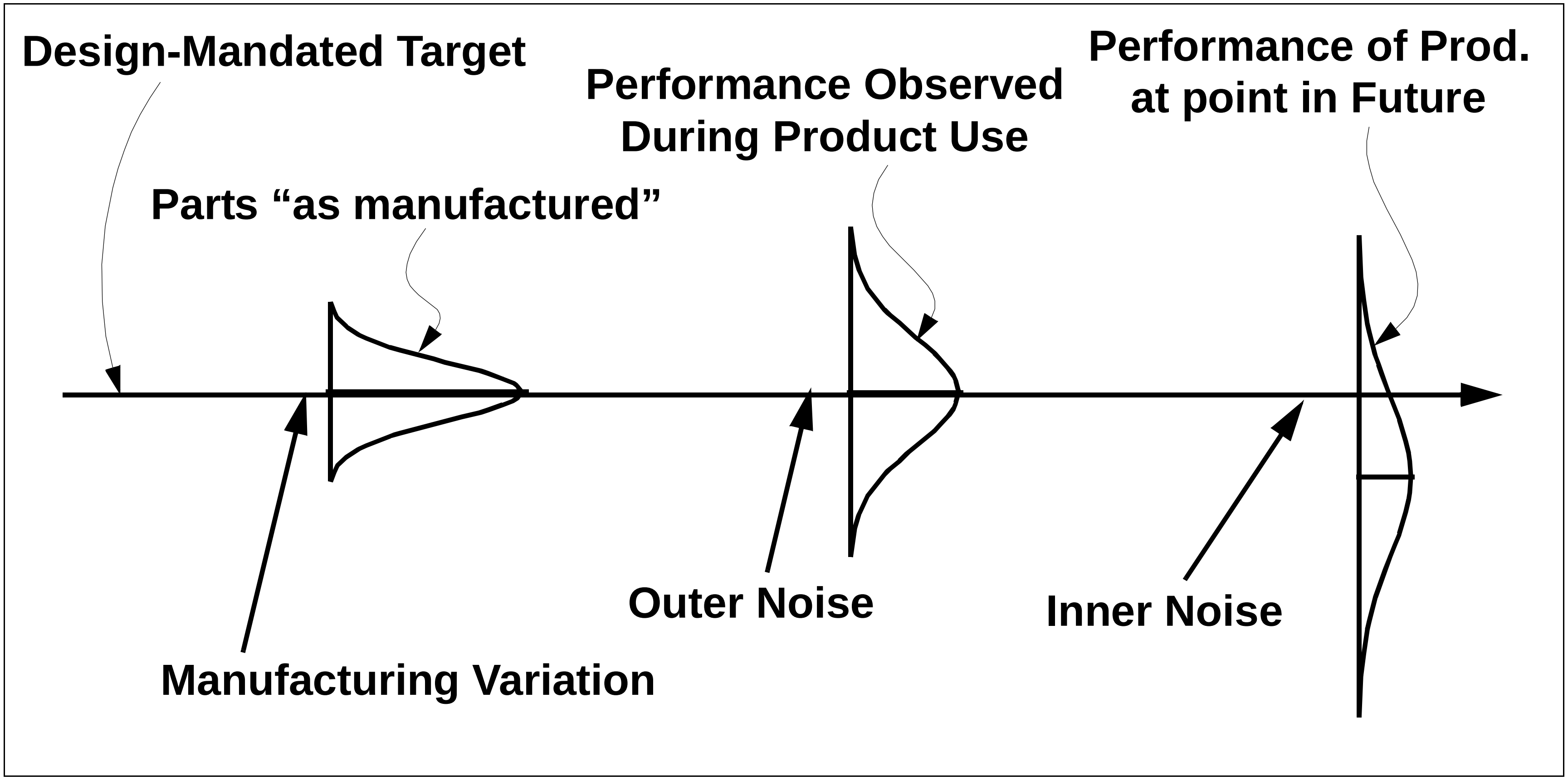
- **Special causes (Deming): sources of variation that arise unpredictably - influence some of the parts. Also referred to as local faults. Sporadic problems (Juran). Often correctable locally at the process.**



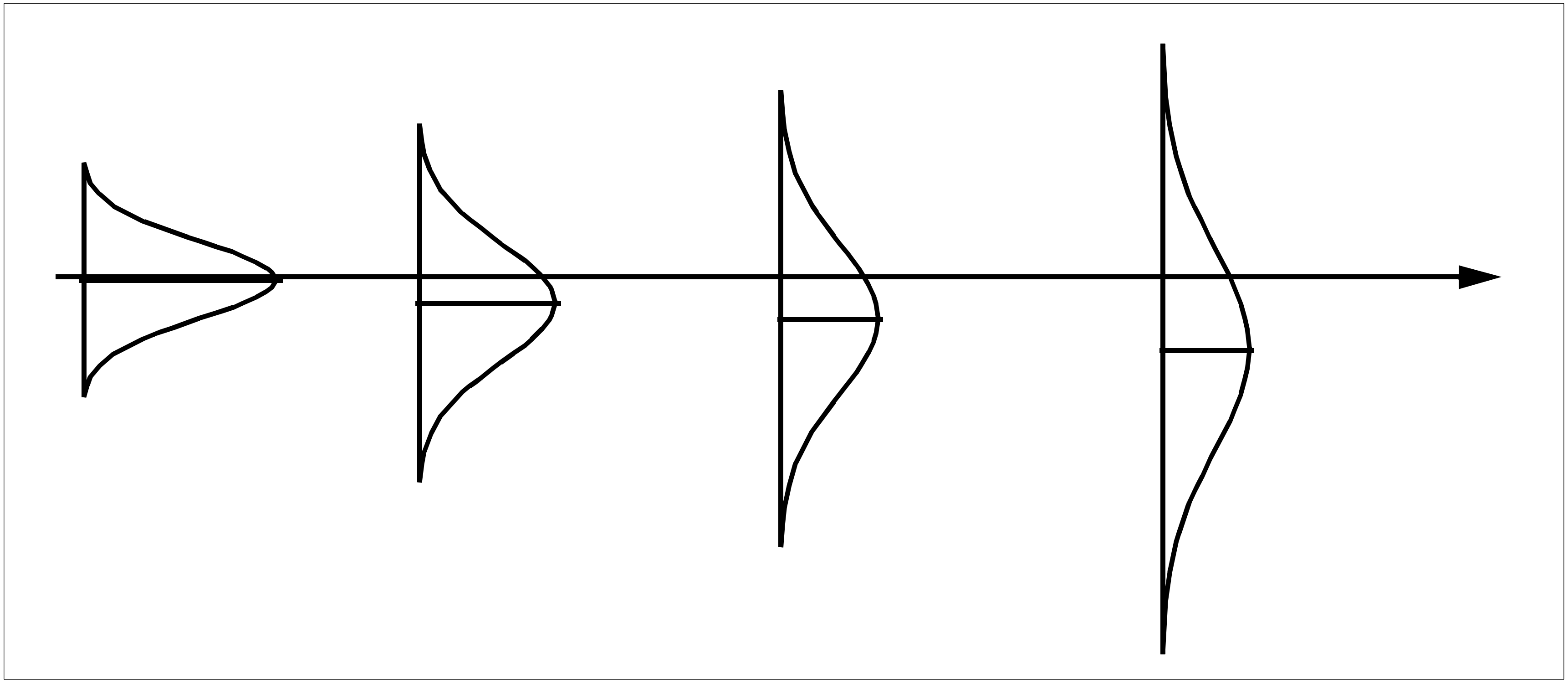
Product Performance Variation



Product Performance Variation (cont.)



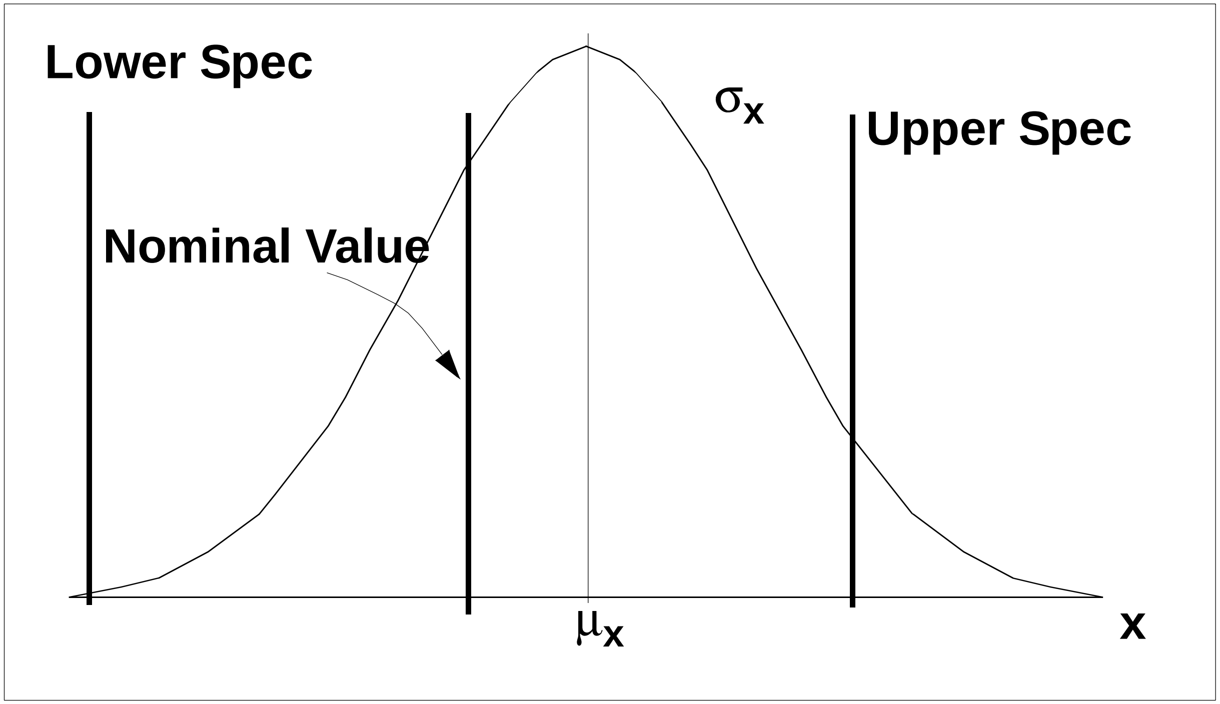
Effect of Wear and Aging



Process mean and variability change over time.

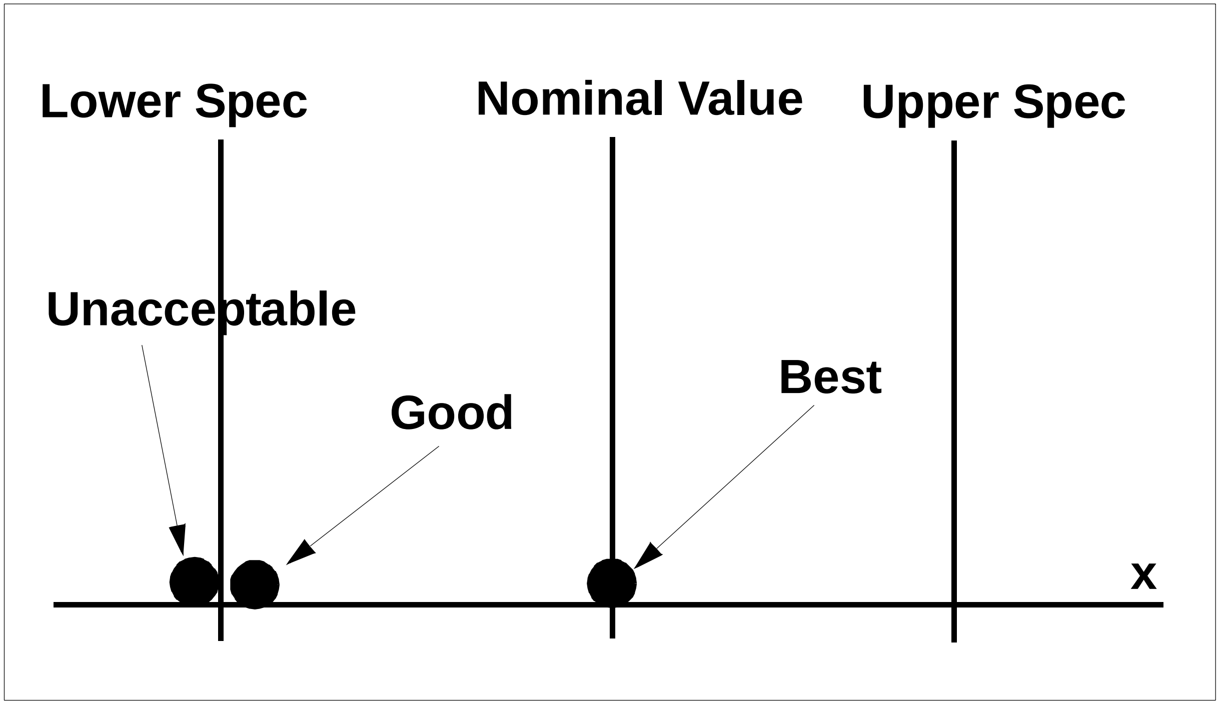
Quality

Traditionally defined as conformance to engineering specifications.



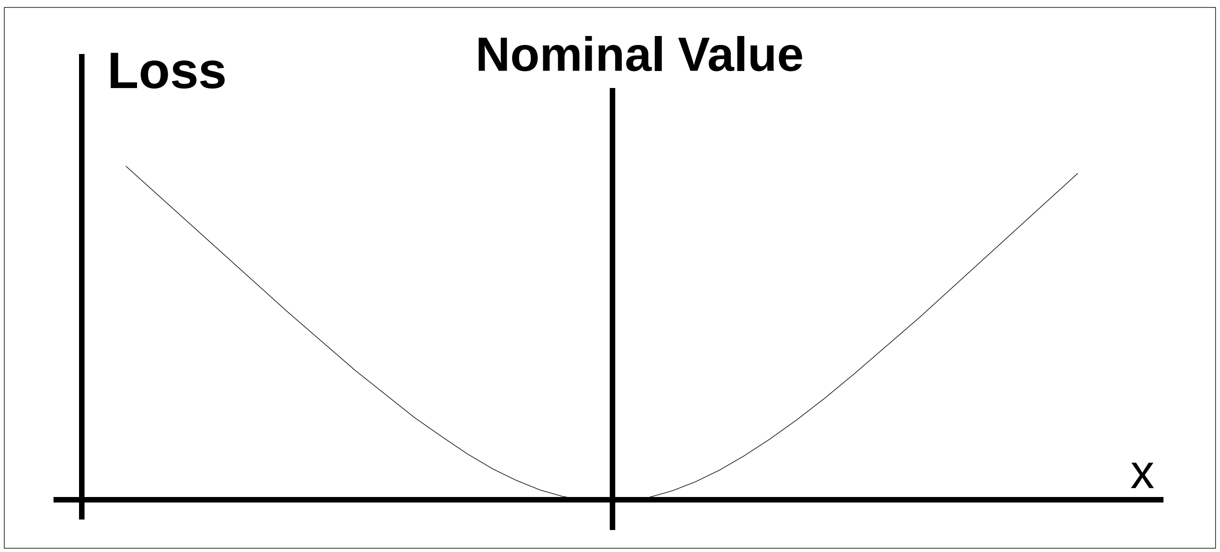
Quality (cont.)

Traditional definition of quality does not promote notion of never-ending improvement.



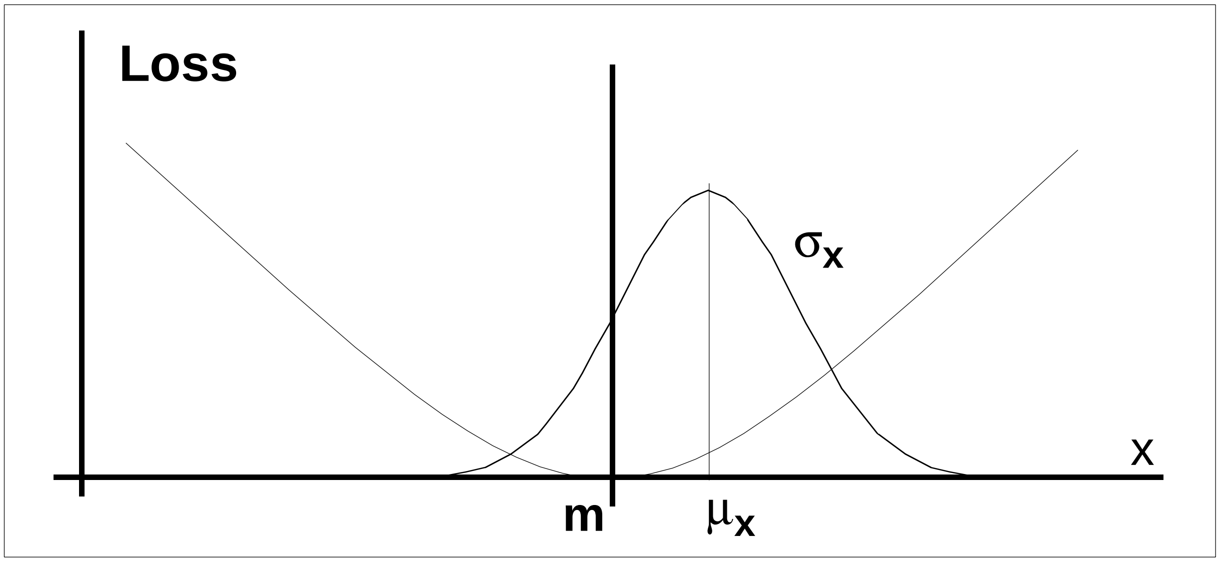
Loss Function

Taguchi advocates the use of a loss function to characterize quality. Quadratic form:



$$L = k(x - m)^2$$

Expected Loss



Since the characteristic X is a random varb., loss is also a random varb. - chararacterizes "average" loss

$$E[L(X)] = k\left[(\mu_x - m)^2 + \sigma_x^2\right]$$

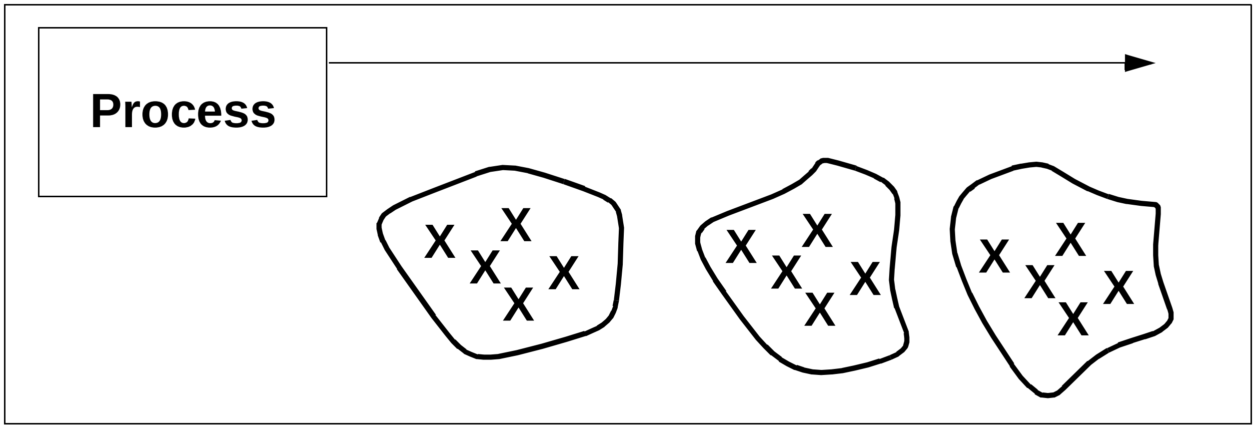
SPC and DOE

Two widely used statistical approaches for improving the process.

- **SPC - Is process stable (predictable, consistent, "in-control)? i.e., free of special causes. Control charts help us identify whether local faults are present.**

- **DOE - Study how a set of variables influence a performance response of interest. What must be done to move a process to a given target value?**

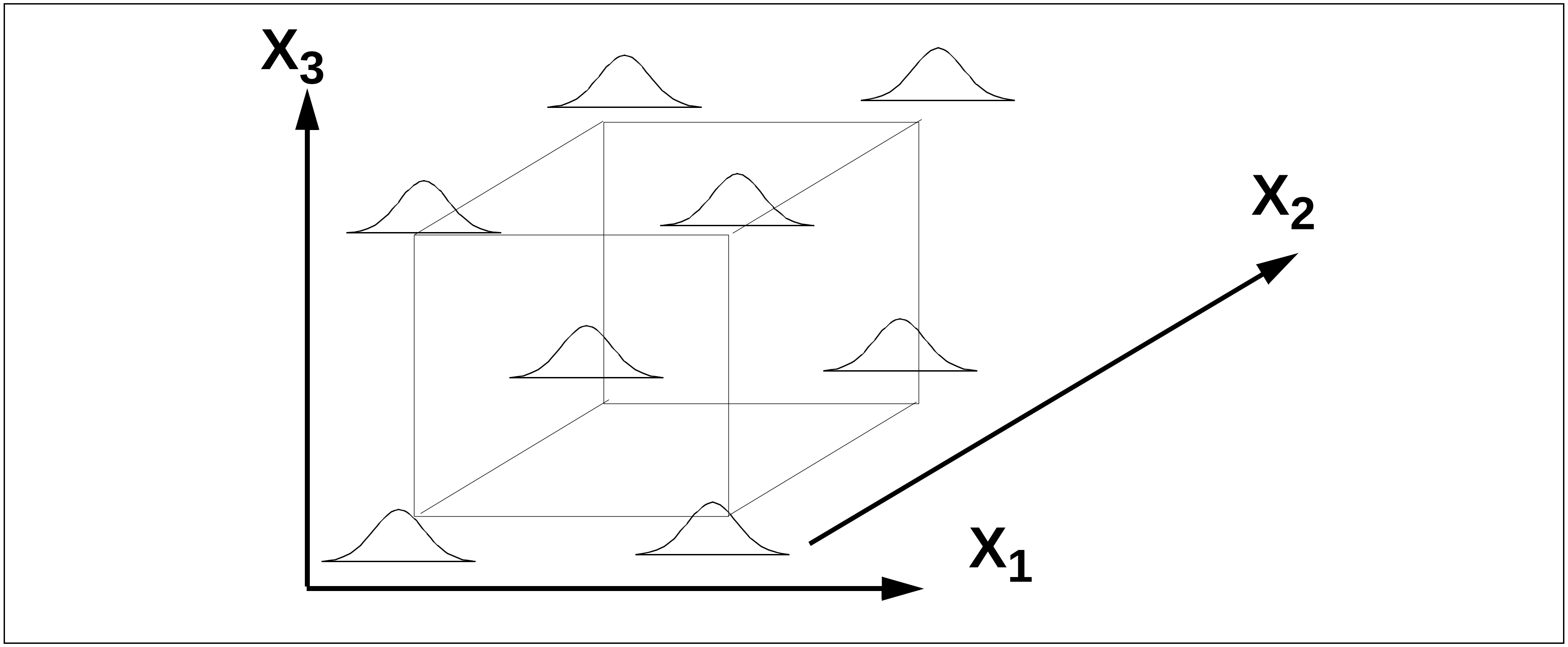
SPC - Control Charts



Samples are collected from the process - use this data to characterize process

For each sample calculate a sample mean and a sample range - plot values versus time

DOE - Designed Experiments

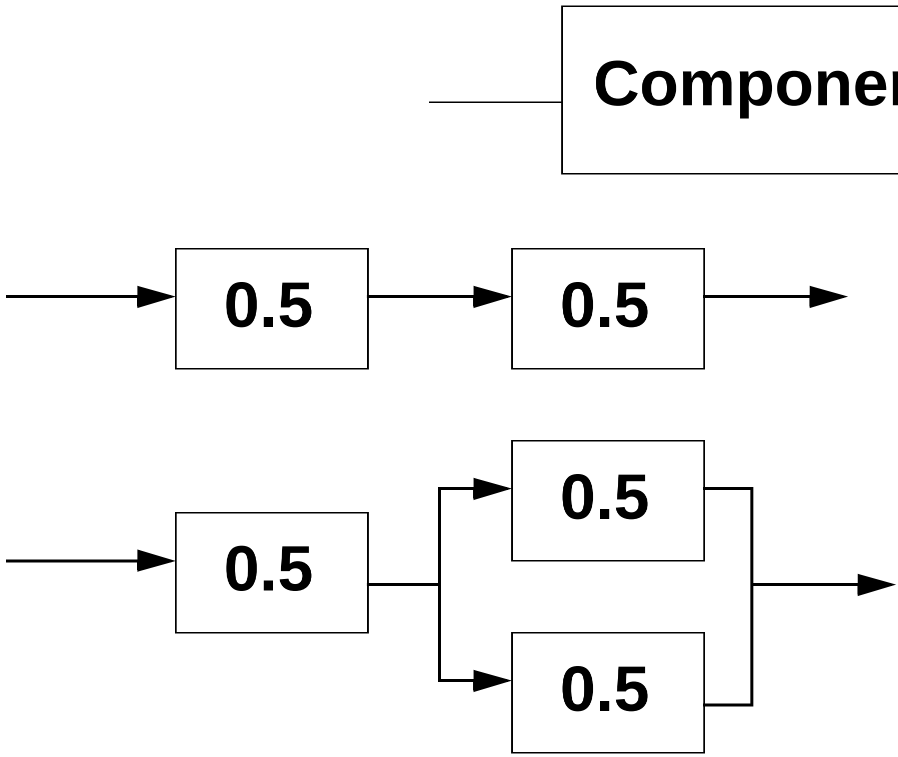


Calculate the effect that each variable has on the process mean and variability (interactions as well).

Modern Quality Principles

- **Never-ending (continuous) improvement**
- **Variation reduction leads to cost reduction and quality improvement (SPC, DOE)**
- **Employ Robust Design principles to reduce effects of manufacturing variation and inner/outer noise.**
- **Improve signal-to-noise ratio by reducing noise rather than increasing signal**

S/N Example - Reliability



$R=(.5)(.5)=0.25$

$R=(.5)(.75)=0.375$

Only fails if both fail, $F=(0.5)^2 = 0.25$
Reliability of parallel comp. = 1-0.25 = 0.75

Failure Distribution

Would like a component to last forever. Reliability is a measure of a component's ability to last over time.

f(t): time to failure probability density

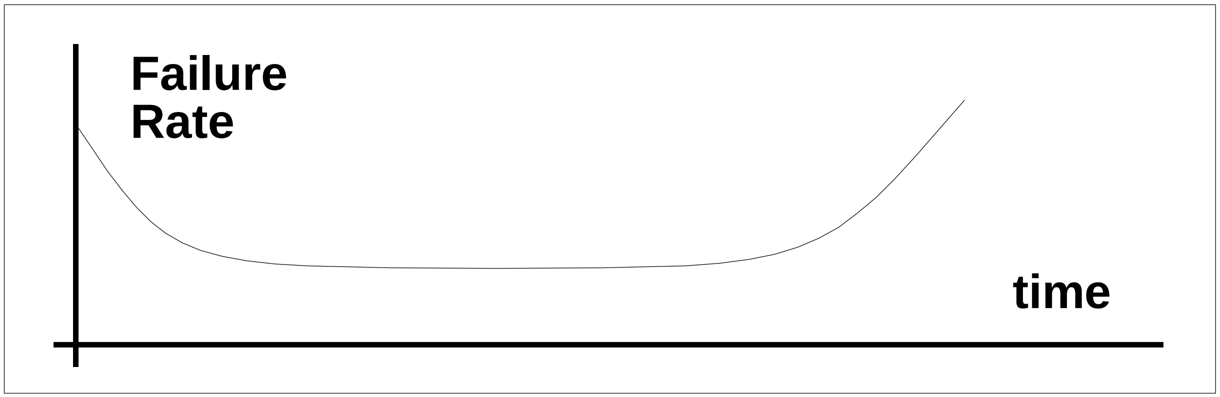
Prob of a failure between (t and t+Δt): f(t)•Δt

Prob. of failure on interval from 0 to t: $F(t) = \int_0^t f(x)\,dx$

Reliability function, R(t) = 1- F(t)

Failure rate: Z(t) = f(t)/R(t)

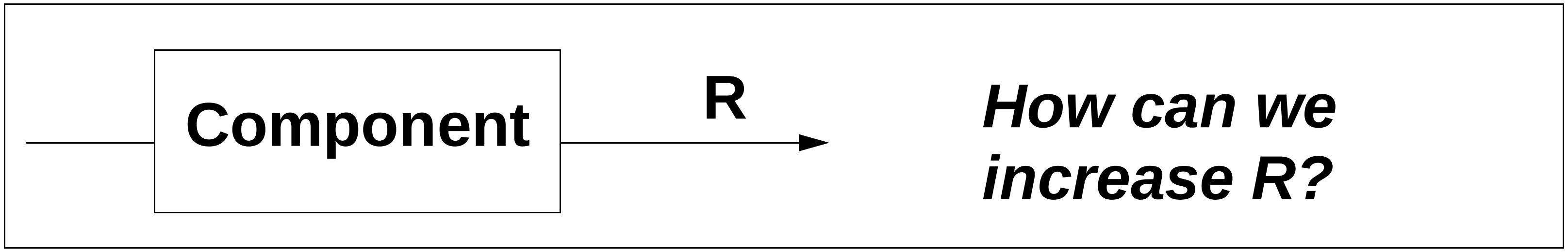
Failure Rate Curve

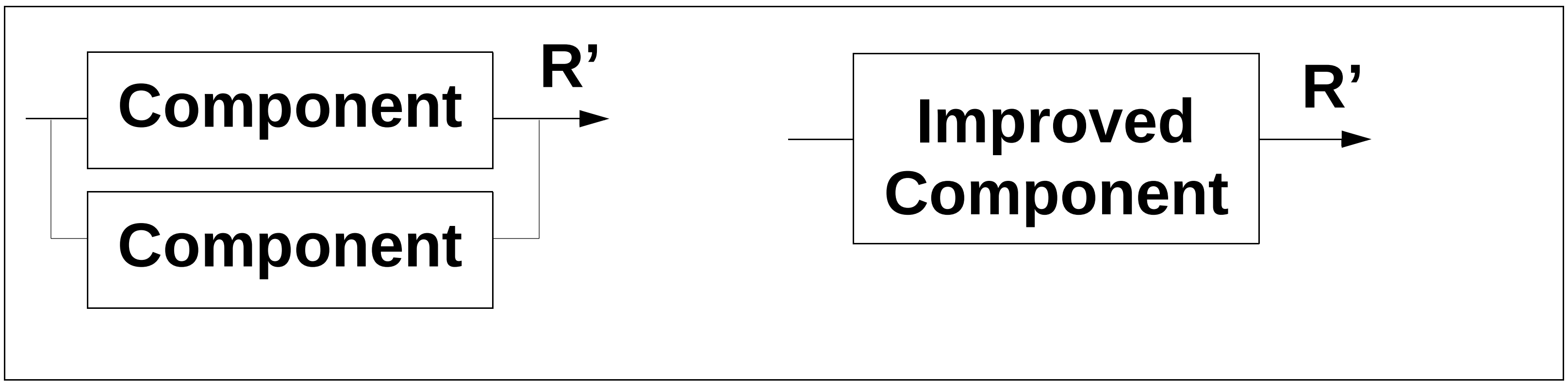


Could assume that for useful part of life, failure rate is constant (α)

Distribution of failure times is exponential: $f(t) = \alpha e^{-\alpha t}$
Time between failures exponentially distributed.

Improving S/N Ratio





Which is preferred?