Lecture # 36

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Six Sigma

Six Sigma Defined: A quality discipline that focuses on product and service excellence to create a culture that demands perfection (on target, every time!)

JWS comment: We will focus on what advocates of 6-sigma are saying and their point of view.

In many cases, the 6-sigma approach is no different from what we have discussed all semester.
Who is Using 6-Sigma as a Key Part of their Corporate Philosophy

Honeywell
Dupont
Dow Chemical
Ford Motor Co.
General Electric
Motorola
Raytheon
Sony
etc.
Steps of Six Sigma

Measure → Analyze

Control → Improve
Key Words

- Critical to Quality (CTQ)
- DMAIIC (Define, Measure, Analyze, Improve, Implement, Control)
- DFSS (Design for Six Sigma)
- DPMO (Defects Per Million Opportunities)
- Design of Experiments (DOE)
- Failure Mode Effects Analysis (FMEA)
- Gage Repeatability & Reproducibility (Gage R&R)
- Quality Function Deployment (QFD)
- Defect Per Unit (DPU)
Measurement System

Identify the CTQ’s

Define Defect Opportunities

Look for Defects in Products or Services

Arrive at DPMO

Convert DPMO to Sigma Level
Six Sigma Roles

- Champion
- Black Belts
- Master Black Belts
- Green Belts
- Yellow Belts
Core Principles of Six Sigma

• Focus on Customer Satisfaction

• Improve Profit through increased revenue and reduced costs

• Improve Performance Project-by-Project

Prioritize:
- projects based on their impact on business
- defects/errors based on what matters most to customer and their impact on the cost structure of the product or service
Core Principles of Six Sigma (Cont.)

- Manage the Organization as a system of connected processes
- Apply PDCA approach: Plan-Do-Check-Act
- Pursue near perfection
- Use the full range of statistical tools that are available for analyzing and solving problems
- Respect and build upon knowledge, experience and dedication of people throughout the organization
Quick Review

We know that common cause variation produces “natural tolerances” of $\pm 3\sigma$. This is a capability of 99.73%. About 3 parts in 1000 will fall outside the specifications.
Interpreting Capability

Is 99.73% capability good enough? 3 bad parts out of 1000 -- isn’t this ok?

Consider a product with multiple parts -- all parts must work for product to function.

For a Series System

\[ R_{system} = \prod_{i=1}^{n} R_i \quad (\text{Product Law of Reliabilities}) \]

where \( n \) is the number of components.
Overall product quality is really bad (individual capability is 99.73%) as number of products gets greater than 20.
Moving Beyond $\pm 3\sigma$

So if our products contain anything more than just a few parts, then $\pm 3\sigma$ (99.73%) just isn’t good enough.

We need to consider higher capabilities for ind. parts
Capability Behavior

Tail Area vs. Z

The graph shows the relationship between the tail area and the variable Z. The tail area decreases as Z increases, indicating a decreasing probability of failure or a decreasing capability index.
## Capability Behavior

<table>
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<tr>
<th>Z</th>
<th>Capability</th>
<th>~ Defective</th>
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<tbody>
<tr>
<td>1</td>
<td>68.26894805%</td>
<td>3/10</td>
</tr>
<tr>
<td>1.5</td>
<td>86.63855424%</td>
<td>15/100</td>
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<tr>
<td>2</td>
<td>95.44998759%</td>
<td>5/100</td>
</tr>
<tr>
<td>2.5</td>
<td>98.75806403%</td>
<td>1/100</td>
</tr>
<tr>
<td>3</td>
<td>99.73000656%</td>
<td>3/1000</td>
</tr>
<tr>
<td>3.5</td>
<td>99.95346533%</td>
<td>5/10000</td>
</tr>
<tr>
<td>4</td>
<td>99.99366279%</td>
<td>60 ppm</td>
</tr>
<tr>
<td>4.5</td>
<td>99.99931984%</td>
<td>7 ppm</td>
</tr>
<tr>
<td>5</td>
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<tr>
<td>5.5</td>
<td>99.999999619%</td>
<td>40 ppb</td>
</tr>
<tr>
<td>6</td>
<td>99.99999980%</td>
<td>2 ppb</td>
</tr>
</tbody>
</table>

* Numbers from EXCEL
Effect of Capability on System Qual.

4 sigma

Prob. System Fcns. vs. # Parts
Effect of Capability on System Qual.

5 sigma

Probability of System Functions vs. Number of Parts

Michigan Tech

Quality Engineering (MEEM 4650 / 5650)
Dept. of Mechanical Engineering - Engineering Mechanics
Michigan Technological University

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Effect of Capability on System Qual.

6 sigma

# Parts

Prob. System Fcns.
Robustness to Process Problems

If process mean shifts ± 1.5σ, process closest spec remains 4.5σ away

Resulting system capability is still pretty good: ~3ppm