Chapter 2- The DMAIC Process
Learning Objectives

1. Understand the importance of selecting good projects for improvement activities.
2. Explain the five steps of DMAIC: Define, Measure, Analyze, Improve, and Control.
3. Explain the purpose of tollgate reviews.
4. Understand the decision-making requirements of the tollgate review for each DMAIC step.
5. Know when and when not to use DMAIC.
6. Understand how DMAIC fits into the framework of the six-sigma philosophy.
DMAIC

• DMAIC is a structure problem-solving technique consisting of the following steps:
  – Define
  – Measure
  – Analyze
  – Improve
  – Control

• DMAIC is usually associated with six sigma, but it can be used with any business or process improvement effort
Considering DMAIC as Tollgate

**Figure 2.1** The DMAIC process.

**Define**
- Define Opportunities
  - Identify and/or validate the business improvement opportunity
  - Define critical customer requirements
  - Document (map) processes
  - Establish project charter, build team

**Measure**
- Measure Performance
  - Determine what to measure
  - Manage measurement data collection
  - Develop and validate measurement systems
  - Determine sigma performance level

**Analyze**
- Analyze Opportunity
  - Analyze data to understand reasons for variation and identify potential root causes
  - Determine process capability, throughput, cycle time
  - Formulate, investigate, and verify root cause hypotheses.

**Improve**
- Improve Performance
  - Generate and quantify potential solutions
  - Evaluate and select final solution
  - Verify and gain approval for final solution

**Control**
- Control Performance
  - Develop ongoing process management plans
  - Mistake-proof process
  - Monitor and control critical process characteristics
  - Develop out of control action plans
<table>
<thead>
<tr>
<th>Tool</th>
<th>Define</th>
<th>Measure</th>
<th>Analyze</th>
<th>Improve</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project charter</td>
<td>Chapter 2</td>
<td>Chapter 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process maps &amp; flow charts</td>
<td>Chapter 2</td>
<td></td>
<td>Chapter 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cause-and-effect analysis</td>
<td>Chapter 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process capability analysis</td>
<td>Chapters 6, 8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypothesis tests, confidence intervals</td>
<td></td>
<td>Chapter 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression analysis, other multivariate methods</td>
<td></td>
<td>Chapter 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gauge R&amp;R</td>
<td></td>
<td>Chapter 8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failure mode &amp; effects analysis</td>
<td></td>
<td>Chapter 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Designed experiments</td>
<td></td>
<td>Chapters 13, 14</td>
<td>Chapters 13, 14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPC and process control plans</td>
<td>Chapters 5, 6, 7, 9, 10, 11, 12</td>
<td>Chapters 5, 6, 7, 9, 10, 11, 12</td>
<td>Chapters 5, 6, 7, 9, 10, 11, 12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Projects

• Essential part of DMAIC
• Breakthrough opportunity
• Financial systems integration
• Value opportunity of a project must be clear
• Project selection
• Project management
If want to improve operating level
• from $4\sigma$ (6,210 ppm defective, assuming $1.5\sigma$ shift in the mean)
• to $6\sigma$ (3.4 ppm defective)
• 25% improvement every year

$$3.4 = 6210(1-0.25)^x$$

• It take about 34 years

If the improvement goal is 50%, then $x = 11$ years, and if it’s 75% then $x = 5$ years.

Must focus on projects that have high impact
## 2.2 The Define Step

<table>
<thead>
<tr>
<th>Business Case</th>
<th>Opportunity Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>• This project supports the business quality goals, namely a) reduce customer resolution cycle time by ( x )% and b) improve customer satisfaction by ( y )%</td>
<td>• An opportunity exists to close the gap between our customer expectations and our actual performance by reducing the cycle time of the customer return process.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Goal Statement</th>
<th>Project Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reduce the overall response cycle time for returned product from our customers by ( x )% year to year.</td>
<td>• Overall response cycle time is measured from the receipt of a product return to the time that either the customer has the product replaced or the customer is reimbursed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Plan</th>
<th>Team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity</td>
<td>Start</td>
</tr>
<tr>
<td>Define</td>
<td>6/04</td>
</tr>
<tr>
<td>Measure</td>
<td>6/18</td>
</tr>
<tr>
<td>Analyze</td>
<td>7/15</td>
</tr>
<tr>
<td>Improve</td>
<td>8/15</td>
</tr>
<tr>
<td>Control</td>
<td>9/15</td>
</tr>
<tr>
<td>Track Benefits</td>
<td>11/01</td>
</tr>
</tbody>
</table>

**Figure 2.2** A project charter for a customer returns process.
A process map or value stream map may also be prepared. These should be completed by at least the end of the Measure step.

**Figure 2.3** A SIPOC diagram.
The Define Tollgate

1. Does the problem statement **focus on symptoms**, not on possible causes or solutions
2. Are all key **stakeholders** identified?
3. What evidence to confirm the **value opportunity** of the project?
4. To ensure that the **scope** is neither too small nor too large?
5. **SIPOC diagram** or other high lever process map has been completed?
6. Have any obvious **barriers or obstacles** been ignored?
7. **Action plan** of Measure step reasonable?
2.3 The Measure Step

- Purpose is to evaluate and determine the present process state
- Identify key process input variables (KPIV) and key process output variables (KPOV)
- Data – from historical records, from sampling, from observational studies
- Histograms, box plots, Pareto charts, scatter diagrams, stem-and-leaf diagrams may all be useful
- Measurement systems capability may be important
The Measure Tollgate

1. Process flow chart, value stream map, all major process steps and activities, suppliers and customers, queue length, waiting time, level of work-in-process are well identified
2. List of KPIVs and KPOVs, related to CTQs
3. Measurement system of capability must be documented
4. Any assumptions must be noted
5. Details of measurement such as where, how, valid of data
2.4 The Analyze Step

• Determine cause-and-effect relationships
• Sources of variability – common cause versus assignable cause
• Tools – control charts, hypothesis testing, confidence intervals, regression models, failure modes and effects analysis
• Discrete event simulation
Failure Modes and Effect Analysis (FMEA)

Use to prioritize the different potential sources of variability, failure and defect or error

- A: Score of variability (1-10)
- B: Score of ability to detect failure (1-10)
- C: Score of severity of failure (1-10)

Risk Priority Number (RPN) = ABC
The Analyze Tollgate

1. What opportunities are going to improve?
2. What data and analysis supported to decision?
3. What is desired outcome on KPOVs and CTQs?
4. Are there other opportunities that are not to evaluate, why?
5. Is the project still on track, time and outcomes?
6. Any resources are required?
2.5 The Improve Step

• Process redesign to reduce bottlenecks
• Mistake-proofing
• Statistical tools – particularly designed experiments
• DOX can be applied to either the physical process or a computer model of the process
• Pilot test the solution to confirm that it will solve the problem
The Improve Tollgate

1. Adequate **documentation** was obtained
2. Documents on alternative solutions
3. **Complete results** of pilot test
4. **Plan** to implement to full scale basis
5. Analysis of any **risk of implementing** and appropriate risk management
2.6 The Control Step

- Complete all remaining work on project
- Provide the process owner with a process control plan
- Training documents (if appropriate) should be provided
- Methods and metrics for future audits
- Transition plan to the new process might include a validation step
The Control Tollgate

1. Data of before and after, were the objectives accomplished?
2. Is the process control plan complete? Process monitoring, control chart
3. Essential documents for project owner complete?
4. Summary of lesson learned from the project
5. List of opportunities that were not pursued in the project, for future project
6. List of opportunities to use the results of the project