Measurement Strategies in the CMMI

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Background

- Software measurement remains a challenge for many projects and organizations.
- It is difficult to select a set of measures that are easy to define and collect, yet offer real insight into progress, process, and quality.
- This presentation will discuss strategies for starting and enhancing a CMMI-compliant measurement system.
CMMI
Measurement and Analysis Process Area

- **Purpose**
  - Develop and sustain a measurement capability that is used to support management information needs

- **Involves specifying:**
  - Information needs and measurement objectives
  - Measures
  - Data collection and storage mechanisms
  - Analysis techniques
  - Reporting and feedback mechanisms

- **Written to conform to ISO/IEC 15939, Software Engineering – Software Measurement Process**
Practical Software and Systems Measurement

Measurement Principles

- Measurement is a consistent but flexible process that must be tailored to the unique information needs and characteristics of the project or organization.

- Decision makers must understand what is being measured and trust the information.

- Measurement must be used to be meaningful.

Reference: http://www.psmsc.com

Rick Hefner, "Measurement Strategies in the CMMI", 24 April 2007
Different types of information are needed at different levels of the infrastructure.
Practical Software and Systems Measurement

Analysis Model

- Technology Effectiveness
- Process Performance
- Product Size and Stability
- Resources and Cost
- Schedule and Progress
- Customer Satisfaction
- Product Quality

Rick Hefner, "Measurement Strategies in the CMMI", 24 April 2007
ISO/IEC 15939, Software Engineering - Software Measurement Process
# Measurement and Analysis - Goal 1

<table>
<thead>
<tr>
<th>Goal/Practices</th>
<th>Notes</th>
<th>Typical Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG 1 Align Measurement and Analysis Activities</td>
<td>Measurement objectives and activities are aligned with identified information needs and objectives.</td>
<td>Focus is on alignment with objectives, not just specifying a set of metrics</td>
</tr>
<tr>
<td>SP 1.1 Establish Measurement Objectives</td>
<td>Establish and maintain measurement objectives that are derived from identified information needs and objectives.</td>
<td>See following slide</td>
</tr>
<tr>
<td>SP 1.2 Specify Measures</td>
<td>Specify measures to address the measurement objectives.</td>
<td></td>
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<tr>
<td>SP 1.3 Specify Data Collection and Storage Procedures</td>
<td>Specify how measurement data will be obtained and stored.</td>
<td></td>
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<tr>
<td>SP 1.4 Specify Analysis Procedures</td>
<td>Specify how measurement data will be analyzed and reported.</td>
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</table>
Information Needs & Measurement Objectives

- **Information needs** set requirements for determining the needed metrics

- **Measurement objectives** set requirements for determining the needed metrics collection, storage, analysis, and reporting mechanisms

**Information Needs**
- What types of information are needed by the project?
  - Progress
  - Quality
  - Information needed by the organization
  - Information needed by the customer

**Measurement Objectives**
- What objectives influence how the measures are collected, analyzed, stored, reported?
  - Accuracy
  - Timeliness
  - Security
# Measurement and Analysis - Goal 2

<table>
<thead>
<tr>
<th>Goal/Practices</th>
<th>Notes</th>
<th>Typical Evidence</th>
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</thead>
<tbody>
<tr>
<td><strong>SG 2 Provide Measurement Results</strong></td>
<td>Measurement results that address identified information needs and objectives are provided.</td>
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<tr>
<td><strong>SP 2.1 Collect Measurement Data</strong></td>
<td>Obtain specified measurement data.</td>
<td>Measuremen t collection records</td>
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<tr>
<td><strong>SP 2.2 Analyze Measurement Data</strong></td>
<td>Analyze and interpret measurement data.</td>
<td>Evidence should explicitly show interpretations</td>
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<tr>
<td><strong>SP 2.3 Store Data and Results</strong></td>
<td>Manage and store measurement data, measurement specifications, and analysis results.</td>
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<tr>
<td><strong>SP 2.4 Communicate Results</strong></td>
<td>Report results of measurement and analysis activities to all relevant stakeholders.</td>
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</tbody>
</table>
What Does the Data Mean?

Large number of defects found in high complexity components; will require second review

Defect range indicates an effective review process

Component #

Defects per component

1 1 12 13 14 15 16 17 1

UCL
# Management Styles in the CMMI

<table>
<thead>
<tr>
<th>Level</th>
<th>Process Areas</th>
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</thead>
<tbody>
<tr>
<td>5 Optimizing</td>
<td>Causal Analysis and Resolution</td>
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<tr>
<td></td>
<td>Organizational Innovation and Deployment</td>
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<tr>
<td>4 Quantitatively Managed</td>
<td>Quantitative Project Management</td>
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<td></td>
<td>Organizational Process Performance</td>
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<tr>
<td>3 Defined</td>
<td>Requirements Development</td>
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<td>Technical Solution</td>
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<td>Product Integration</td>
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<td>Verification</td>
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<td>Organizational Process Focus</td>
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<td>Organizational Process Definition</td>
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<td>Organizational Training</td>
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<td>Risk Management</td>
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<td></td>
<td>Integrated Project Management (for IPPD*)</td>
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<td></td>
<td>Integrated Teaming*</td>
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<td></td>
<td>Integrated Supplier Management**</td>
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<td></td>
<td>Decision Analysis and Resolution</td>
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<td></td>
<td>Organizational Environment for Integration*</td>
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<tr>
<td>2 Managed</td>
<td>Requirements Management</td>
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<tr>
<td></td>
<td>Project Planning</td>
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<td></td>
<td>Project Monitoring and Control</td>
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<tr>
<td></td>
<td>Supplier Agreement Management</td>
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<td>Process and Product Quality Assurance</td>
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<td>Configuration Management</td>
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Rick Hefner, "Measurement Strategies in the CMMI", 24 April 2007
Measurement at CMMI Level 4

- **Organizational Process Performance**
  - Establishes a quantitative understanding of the performance of the organization’s set of standard processes
  - Provides process performance data, baselines, and models to quantitatively manage the organization’s projects

- **Quantitative Project Management**
  - Quantitatively manage the project’s defined process to achieve the project’s established quality and process-performance objectives.
Exercise
What is Quantitative Management?

- Suppose your project conducted several peer reviews of similar code, and analyzed the results
  - Mean = 7.8 defects/KSLOC
  - $+3\sigma = 11.60$ defects/KSLOC
  - $-3\sigma = 4.001$ defects/KSLOC

- What would you expect the next peer review to produce in terms of defects/KSLOC?

- What would you think if a review resulted in 10 defects/KSLOC?

- 3 defects/KSLOC?
Exercise
What is Required for Quantitative Management?

- What is needed to develop the statistical characterization of a process?
  - The process has to be stable (predictable)
    - Process must be consistently performed
    - Complex processes may need to be stratified (separated into simpler processes)
  - There has to be enough data points to statistically characterize the process
    - Processes must occur frequently within a similar context (project or organization)

![Control Chart](chart.png)

- Observation Number
- Individual Value
- Mean = 7.8
- UCL = 11.60
- LCL = 4.001

Rick Hefner, "Measurement Strategies in the CMMI", 24 April 2007
Typical Choices in Industry

- Most customers care about:
  - Delivered defects
  - Cost and schedule

- So organizations try to predict:
  - Defects found throughout the lifecycle
  - Effectiveness of peer reviews, testing
  - Cost achieved/actual (Cost Performance Index – CPI)
  - Schedule achieved/actual (Schedule Performance Index – SPI)

**Defect Detection Profile**

- Process performance
  - Process measures (e.g., effectiveness, efficiency, speed)
  - Product measures (e.g., quality, defect density).
Measurement at CMMI Level 5

- **Organizational Innovation & Deployment**
  - Set quantitative improvement goals (e.g., reduce variation by X%, reduce mean by Y%)
  - Seek innovative improvements - cause a shift in process capability
  - Analyze potential improvements to estimate costs and impacts (benefits)
  - Pilot improvements to ensure success
  - Measure the impact of improvements quantitatively (variation and mean)

- **Causal Analysis & Resolution**
  - Identify and analyze causes of defects and other problems
  - Take specific actions to remove the causes - prevent the occurrence of those types of defects and problems in the future
Peer Reviews - Improving the Process

- **Reduce the variation**
  - Train people on the process
  - Create procedures/checklists
  - Strengthen process audits

- **Increase the effectiveness (increase the mean)**
  - Train people
  - Create checklists
  - Reduce waste and re-work
  - Replicate best practices from other projects

![Control Chart with Means and Limits]

- **Mean** = 7.268
- **UCL** = 11.17
- **LCL** = 3.363

Rick Hefner, "Measurement Strategies in the CMMI", 24 April 2007
Lessons Learned

- To establish (revitalize) a measurement system, start by identifying all the stakeholders and what information they need to make decisions
  - Look for common needs, which drive common metrics that can be used by many stakeholders
  - There is no “magic” set of metrics that works for every project or every organization

- It takes several months, if not years, to develop an effective measurement system
  - Initially, focus is on ensuring data is provided
  - Next, focus in on data definition problems
  - Finally, focus on effective use of the data
  - Concentrate on developing a data-driven culture

- When moving to Levels 4 and 5, expect a period of trial-and-error to discover the metrics you need
  - Focus on management by variation (e.g., Six Sigma)