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.
Agenda

- Measurement Principles
- CMMI Measurement and Analysis Practices
- Typical Measures by Maturity Level
- Lessons Learned
What is the Capability Maturity Model Integration?

- The CMMI is a collection of industry best-practices for engineering and management
  - Developed under the sponsorship of DoD
  - Consistent with DoD and commercial standards
  - Addresses both software and systems engineering, project and organizational practices

<table>
<thead>
<tr>
<th>Project Management</th>
<th>Engineering</th>
<th>Support</th>
<th>Process Management</th>
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<tbody>
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<td>Project Planning</td>
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<td>Quantitative Project Management</td>
<td>Validation</td>
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Rick Hefner, "Measurement Strategies in the CMMI", 2007
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 Measurement

ISO/IEC 15939, Software Measurement Process

CMMI Measurement And Analysis

ISO/IEC SC7 Standards
- 12207 (revision – supporting process)
- 15288 (measurement concepts)
- 9126 (terminology coordinated)
- 14598 (terminology coordinated)
- ISO 9000-3:2000 (objectives)
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", 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", 2007
ISO/IEC 15939, Software Engineering - Software Measurement Process

Information Needs

Information Product

- Interpretation
- Indicator

Analysis Model

- Derived Measure
- Derived Measure

Measurement Function

- Base Measure
- Base Measure

Measurement Method

- Measurement Method
- Measurement Method

Entities

Attribute

Property Relevant to Information Needs

Rick Hefner, "Measurement Strategies in the CMMI", 2007
## Measurement and Analysis - Goal 1

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

Rick Hefner, "Measurement Strategies in the CMMI", 2007
# CMMI
## Measurement and Analysis - Goal 2

<table>
<thead>
<tr>
<th>Goal/Practices</th>
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<th>Typical Evidence</th>
</tr>
</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>
<td>Following defined procedures</td>
</tr>
<tr>
<td><strong>SP 2.1 Collect Measurement Data</strong></td>
<td>Obtain specified measurement data.</td>
<td>Measurement collection records</td>
</tr>
<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>
</tr>
<tr>
<td><strong>SP 2.3 Store Data and Results</strong></td>
<td>Manage and store measurement data, measurement specifications, and analysis results.</td>
<td>Data storage records</td>
</tr>
<tr>
<td><strong>SP 2.4 Communicate Results</strong></td>
<td>Report results of measurement and analysis activities to all relevant stakeholders.</td>
<td>Metrics reports/ briefings</td>
</tr>
</tbody>
</table>

*Rick Hefner, "Measurement Strategies in the CMMI", 2007*
What Does the Data Mean?

Defects per component

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

Defect range indicates an effective review process

Rick Hefner, "Measurement Strategies in the CMMI", 2007
# Management Styles in the CMMI

## Project

<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>
</tr>
<tr>
<td></td>
<td>Organizational Innovation and Deployment</td>
</tr>
<tr>
<td>4 Quantitatively Managed</td>
<td>Quantitative Project Management</td>
</tr>
<tr>
<td></td>
<td>Organizational Process Performance</td>
</tr>
<tr>
<td>3 Defined</td>
<td>Requirements Development</td>
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<td></td>
<td>Technical Solution</td>
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<td></td>
<td>Risk Management</td>
</tr>
<tr>
<td></td>
<td>Integrated Project Management (for IPPD*)</td>
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<td></td>
<td>Integrated Teaming*</td>
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<tr>
<td></td>
<td>Integrated Supplier Management**</td>
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<tr>
<td></td>
<td>Decision Analysis and Resolution</td>
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<tr>
<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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<td>Configuration Management</td>
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<tr>
<td>1 Performed</td>
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Rick Hefner, "Measurement Strategies in the CMMI", 2007
# CMMI Level 2

## Measurement - Project Planning

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<tbody>
<tr>
<td><strong>SG 1 Establish Estimates</strong>&lt;br&gt; Estimates of project planning parameters are established and maintained.</td>
<td></td>
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</tr>
</tbody>
</table>
| **SP 1.2 Establish Estimates of Work Product and Task Attributes**<br> Establish and maintain estimates of the attributes of the work products and tasks. | Attributes are characteristics used to determine effort  
- Size (e.g., SLOC)  
- Complexity (e.g., COCOMO parameters)  
Will be tracked in PMC | Parametric model parameters |
<p>| <strong>SP 1.4 Determine Estimates of Effort and Cost</strong>&lt;br&gt; Estimate the project effort and cost for the work products and tasks based on estimation rationale. | Effort/cost estimates | |
| <strong>SG 2 Develop a Project Plan</strong>&lt;br&gt; A project plan is established and maintained as the basis for managing the project. | | |
| <strong>SP 2.1 Establish the Budget and Schedule</strong>&lt;br&gt; Establish and maintain the project’s budget and schedule. | Budget, schedule | |</p>
<table>
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</thead>
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<td>SG 1 Monitor Project Against Plan</td>
<td>Actual performance and progress of the project are monitored against the project plan.</td>
<td>Periodic metrics reports</td>
</tr>
<tr>
<td>SP 1.1 Monitor Project Planning Parameters</td>
<td>Monitor the actual values of the project planning parameters against the project plan.</td>
<td>See PP SP 1.2 and 1.4; includes monitoring of attributes against estimates</td>
</tr>
</tbody>
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### CMMI Level 3

**Measurement - Integrated Project Management**

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<th>Goal/Practices</th>
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<tr>
<td><strong>SG 1 Use the Project’s Defined Process</strong></td>
<td>The project is conducted using a defined process that is tailored from the organization's set of standard processes.</td>
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</tr>
<tr>
<td><strong>SP 1.5 Manage the Project Using the Integrated Plans</strong></td>
<td>Manage the project using the project plan, the other plans that affect the project, and the project’s defined process.</td>
<td>Proactive management may be expected Discuss with Lead Appraiser</td>
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<tr>
<td></td>
<td></td>
<td>Metrics reports</td>
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- **Informative material in the CMMI suggests that project management becomes more proactive at Level 3**
  - Monitoring the activities that could significantly affect the actual values of the project’s planning parameters
  - Tracking the project’s planning parameters using measurable thresholds that will trigger investigation and appropriate actions
  - Risk management
  - Earned value management

*Rick Hefner, "Measurement Strategies in the CMMI", 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)

\[ \text{Mean} = 7.8 \]
\[ \text{UCL} = 11.60 \]
\[ \text{LCL} = 4.001 \]

Observation Number

Individual Value

Rick Hefner, "Measurement Strategies in the CMMI", 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)

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**Defect Detection Profile**

- **Process performance**
  - **Process measures** (e.g., effectiveness, efficiency, speed)
  - **Product measures** (e.g., quality, defect density).

*Rick Hefner, "Measurement Strategies in the CMMI", 2007*
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

**Graph:**
- Observation Number
- Individual Value
- UCL = 11.17
- Mean = 7.268
- LCL = 3.363

*Rick Hefner, "Measurement Strategies in the CMMI", 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 than 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)