Capability Maturity Model Integration (CMMI)

Introduction and Overview

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– PhD Computing Science, Univ. of Manchester
  • Quality assurance, quality management, ISO 9000
  • Senior consultant, project lead
  • Quality management, internal CMM(I) consultant, development processes, project management
– Since 2003: Independent consultant on CMMI
– Speaker of GI SIG on software processes
– SEI-Authorized CMM Lead Assessor, CMMI Lead Appraiser
– Coordinator of the German CMM(I) Lead Appraiser and Instructor Board (CLIB)

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Dr. Ralf Kneuper, 11.03.2005
Where do I find out more about CMMI?

Original CMMI documentation

- Capability Maturity Model Integration (CMMI), CMMI for Systems Engineering and Software Engineering (CMMI-SE/SW, V1.1) Continuous Representation CMU/SEI-2002-TR-001
- Capability Maturity Model Integration (CMMI), CMMI for Systems Engineering and Software Engineering (CMMI-SE/SW, V1.1) Staged Representation CMU/SEI-2002-TR-002
  - both available at http://www.sei.cmu.edu/cmmi

Further reading

- see also http://www.kneuper.de/cmmi/cmmi-lit.htm
Underlying Premise of Process Improvement

“The quality of a product is largely determined by the quality of the process that is used to develop and maintain it.”

Based on TQM principles as taught by Shewhart, Juran, Deming and Humphrey.
Why do we want software process improvement (CMM, CMMI, ...)?

- **What does the customer want?**
  - High-quality results that satisfy the requirements and are completed in time and in budget

- **What does the management want?**
  - High customer satisfaction
  - High productivity
  - Control over projects

- **What do the developers want?**
  - Do their job in peace

Software Process Improvement (SPI) supports achieving these goals!
Versions of CMM(I)

1987: Software process maturity framework
1991: Capability Maturity Model Version 1.0
1993: Capability Maturity Model Version 1.1
1998: Draft of Capability Maturity Model Version 2.0
2000: Capability Maturity Model Integration Version 1.0
2002: Capability Maturity Model Integration Version 1.1
2006: Planned: CMMI 1.2

Emphasis in Assessments on Maturity Questionnaire
Withdrawn in order to restructure the model
Capability Maturity Model Integration (CMMI) Project

- Project started in 1997
- CMMI-SE/SW Version 1.0 released in August 2000
- CMMI-SE/SW Version 1.1 released in January 2002
  - „staged“ and „continuous“ representation
  - one common document covering Systems and Software Engineering
  - some additional requirements compared to SW-CMM 1.1
  - in some cases requirements are stated more explicitly
    - mainly requirements that were obviously meant but not stated explicitly
    - SPICE (ISO 15504) - conformant
  - More structure, higher abstraction level
- “Sunset period” until end of 2003
- Revised assessment method („SCAMPI“ instead of „CBA-IPI“)
The five maturity levels of CMMI

1. Initial
   - Unpredictable, little control

2. Managed
   - Can repeat earlier successes
   - Controlled process
   - Project management
   - Standardised consistent process

3. Defined
   - Process documented, well understood
   - Predictable process

4. Quant. Managed
   - Process measured and controlled
   - Comprehensive development process
   - Managing change

5. Optimizing
   - Process improvement
   - Continuous process improvement
   - Increased productivity and quality

Product and process quality
Reduced risk

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Structure of CMMI
Staged Representation

Maturity Levels

Process Area 1
Process Area 2
Process Area n

Specific Goals
Generic Goals

Specific Practices
Generic Practices

Common features will be removed in CMMI v1.2 since they are no longer relevant
## Variants of CMMI

<table>
<thead>
<tr>
<th>Representation / Application area</th>
<th>Continuous Representation</th>
<th>Staged Representation</th>
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</thead>
<tbody>
<tr>
<td>System engineering (SE)</td>
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<tr>
<td>Software engineering (SW)</td>
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<td>X</td>
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<tr>
<td>Integrated product and process development (IPPD)</td>
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<td>X</td>
</tr>
<tr>
<td>Supplier Sourcing (SS)</td>
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<td>X</td>
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</table>
Levels

• Capability Level (Continuous representation)
  - Capability levels apply to one process area
  - Capability levels range from 0 (no requirements) to 5

• Maturity Level (Staged representation)
  - Maturity levels apply to the totality of all process areas
  - Maturity levels range from 1 (no requirements) to 5
CMMI

**Maturity Levels vs. Capability Levels**

### Maturity Levels

- **1 Initial**
  - Processes are ad-hoc

- **2 Managed**
  - Processes are defined by the organization

- **3 Defined**
  - Processes are measured and controlled

- **4 Quantitatively managed**
  - Focus on process improvement

- **5 Optimizing**
  - Processes are characterized by the project

### Capability Levels

- **0 Incomplete**
- **1 Performed**
- **2 Managed**
- **3 Defined**
- **4 Quantitatively managed**
- **5 Optimizing**
Generic Goal Level 1

• Achieve Specific Goals (GG 1)
  – Perform Base Practices (GP 1.1)
Generic Goal Level 2
Managed Process

• Institutionalize a Managed Process (GG 2)
  – Establish an Organizational Policy (GP 2.1)
  – Plan the Process (GP 2.2)
  – Provide Resources (GP 2.3)
  – Assign Responsibility (GP 2.4)
  – Train People (GP 2.5)
  – Manage Configurations (GP 2.6)
  – Identify and Involve Relevant Stakeholders (GP 2.7)
  – Monitor and Control the Process (GP 2.8)
  – Objectively Evaluate Adherence (GP 2.9)
  – Review Status with Higher Level Management (GP 2.10)

Careful: in CMM, "managed" referred to level 4
Generic Goal Level 3
Defined Process

- Institutionalize a Defined Process (GG 3)
  - Establish a Defined Process (GP 3.1)
  - Collect Improvement Information (GP 3.2)
Generic Goal Level 4 / 5
Quantitatively Managed Process / Optimizing Process

• Institutionalize a Quantitatively Managed Process (GG 4)
  – Establish Quantitative Objectives for the Process (GP 4.1)
  – Stabilize Subprocess Performance (GP 4.2)

• Institutionalize an Optimizing Process (GG 5)
  – Ensure Continuous Process Improvement (GP 5.1)
  – Correct Root Causes of Problems (GP 5.2)

• GG 4 and GG 5 are only contained in the continuous representation
Agenda

• Introduction
• History and Motivation
• Structure of CMMI
• Generic Goals – Overview

Maturity Level 2 and 3 Process Areas
• Generic Goals – Revisited
• CMMI Appraisals
• Introducing CMMI into an Organization
• CMMI and ISO 15504 (SPICE)
### CMMI (CMMI-SE/SW V. 1.1)

#### Process Areas by Category and Maturity Level

<table>
<thead>
<tr>
<th>Maturity Level</th>
<th>Process Management</th>
<th>Engineering</th>
<th>Support</th>
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<tr>
<td>2</td>
<td>Project Planning (PP)</td>
<td>Requirements Management (REQM)</td>
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<td>Project Monitoring and Control (PMC)</td>
<td>Process &amp; Product Quality Assurance (PPQA)</td>
<td>Process &amp; Product Quality Assurance (PPQA)</td>
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<td>Supplier Agreement Management (SAM)</td>
<td>Measurement and Analysis (MA)</td>
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<td>Organizational Process Focus (OPF)</td>
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<td>Decision Analysis and Resolution (DAR)</td>
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<td>5</td>
<td>Organizational Innovation and Deployment (OID)</td>
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<td>Causal Analysis and Resolution (CAR)</td>
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</table>
The purpose of Requirements Management is to manage the requirements of the project's products and product components and to identify inconsistencies between those requirements and the project's plans and work products.
Requirements Management

SG 1 Manage Requirements

- **SP 1.1** Obtain an Understanding of Requirements
- **SP 1.2** Obtain Commitment to Requirements
- **SP 1.3** Manage Requirements Changes
- **SP 1.4** Maintain Bidirectional Traceability of Requirements
- **SP 1.5** Identify Inconsistencies between Project Work and Requirements

**Requirements traceability matrix**

**Requirements documentation**

1 Typical tools:
- requirements list
- requirements database
Project Planning

SG 1 Establish Estimates
- SP 1.1 Estimate the scope of the project
- SP 1.2 Establish Estimates of Work Product and Task Attributes
- SP 1.3 Define Project Life Cycle
- SP 1.4 Determine Estimates of Effort and Cost

SG 2 Develop a Project Plan
- SP 2.1 Establish the Budget and Schedule
- SP 2.2 Identify Project Risks
- SP 2.3 Plan for Data Management
- SP 2.4 Plan for Project Resources
- SP 2.5 Plan for Needed Knowledge and Skills
- SP 2.6 Plan Stakeholder Involvement
- SP 2.7 Establish the Project Plan
- SP 2.8 Plan for Needed Knowledge and Skills

SG 3 Obtain Commitment to the Plan
- SP 3.1 Review Plans that Affect the Project
- SP 3.2 Reconcile Work and Resource Levels
- SP 3.3 Obtain Plan Commitment

Planning data (effort, cost,...)
Supplier Agreement Management

SG 1 Establish Supplier Agreements

SP 1.1 Determine Acquisition Type
SP 1.2 Select Suppliers
SP 1.3 Establish Supplier Agreements

Supplier Agreement (Contract)

Supplier reqs. (acquisition type, supplier list, selection criteria, etc.)

Work Product

SP 2.1 Review COTS\(^1\) Products
SP 2.3 Accept the Acquired Product
SP 2.2 Execute Supplier Agreement
SP 2.4 Transition Product

 grape

Evaluation criteria

Acceptance test (Procedure, result)
Transition plan
Supplier status (progress, reviews, etc.)

\(^1\) COTS = commercial off-the-shelf,
Measurement and Analysis

SG 1 Align Measurement and Analysis Activities

SP 1.1 Establish Measurement Objectives
SP 1.2 Specify Measures
SP 1.3 Specify Data Collection and Storage Procedures
SP 1.4 Specify Analysis Procedures

Measurement Objectives

Analysis, interpretation of measurement data and reports

Metric Repository

Procedures & Tools (for collection and analysis)

SG 2 Provide Measurement Results

SP 2.1 Collect Measurement Data
SP 2.2 Analyze Measurement Data
SP 2.3 Store Data and Results
SP 2.4 Communicate Results

Relevant stakeholder (data supplier or analyst, etc.)
Process and product quality assurance

SG 1 Objectively Evaluate Processes and Work Products

SP 1.1 Objectively Evaluate Processes

SP 1.2 Objectively Evaluate Work Products and Services

Review minutes (deviations)

QA review data base

SG 2 Provide Objective Insight

SP 2.1 Communicate and Ensure Resolution of Noncompliance Issues

SP 2.2 Establish Records

QA reporting (trends, etc.)

Processes & work products
The purpose of Requirements Development is to produce and analyze customer, product, and product-component requirements.
The purpose of Technical Solution is to design, develop, and implement solutions to requirements. Solutions, designs, and implementations encompass products, product components, and product-related lifecycle processes either singly or in combinations as appropriate.
The purpose of Product Integration is to assemble the product from the product components, ensure that the product, as integrated, functions properly, and deliver the product.
The purpose of Verification is to ensure that selected work products meet their specified requirements.
The purpose of Validation is to demonstrate that a product or product component fulfills its intended use when placed in its intended environment.
Verification vs. Validation

• Verification
  – „Do things right“
  – do what was specified previously

• Validation
  – „Do the right thing“
  – do what the customer really needs
The purpose of Organizational Process Focus is to plan and implement organizational process improvement based on a thorough understanding of the current strengths and weaknesses of the organization’s processes and process assets.
The purpose of Organizational Process Definition is to establish and maintain a usable set of organizational process assets.
The purpose of Organizational Training is to develop the skills and knowledge of people so they can perform their roles effectively and efficiently.
The purpose of Integrated Project Management is to establish and manage the project and the involvement of the relevant stakeholders according to an integrated and defined process that is tailored from the organization's set of standard processes.

- SG 1 Use the Project’s Defined Process
  - Establish the Project’s Defined Process
  - Use Organizational Process Assets for Planning Project Activities
  - Integrate Plans
  - Manage the Project Using the Integrated Plans
  - Contribute to the Organizational Process Assets

- SG 2 Coordinate and Collaborate with Relevant Stakeholders
  - Manage Stakeholder Involvement
  - Manage Dependencies
  - Resolve Coordination Issues
The purpose of Risk Management is to identify potential problems before they occur, so that risk-handling activities may be planned and invoked as needed across the life of the product or project to mitigate adverse impacts on achieving objectives.

- **SG 1 Prepare for Risk Management**
  - Determine Risk Sources and Categories
  - Define Risk Parameters
  - Establish a Risk Management Strategy

- **SG 2 Identify and Analyze Risks**
  - Identify Risks
  - Evaluate, Categorize, and Prioritize Risks

- **SG 3 Mitigate Risks**
  - Develop Risk Mitigation Plans
  - Implement Risk Mitigation Plans
• The purpose of Decision Analysis and Resolution is to analyze possible decisions using a formal evaluation process that evaluates identified alternatives against established criteria.

  – SG 1 Evaluate Alternatives
    • Establish Guidelines for Decision Analysis
    • Establish Evaluation Criteria
    • Identify Alternative Solutions
    • Select Evaluation Methods
    • Evaluate Alternatives
    • Select Solutions
Additional Process Areas for Other Disciplines (all Maturity Level 3)

• **CMMI-SE/SW/IPPD**
  – Integrated Teaming (IT)
  – Organizational Environment for Integration (OEI)
  – Integrated Project Management for IPPD (IPM)
    • Two additional goals

• **CMMI-SE/SW/IPPD/SS**
  – Integrated Supplier Management (ISM)
Rough timeline for a SCAMPI Appraisals

- Decision to have assessment, select lead assessor
  - 1 - 2 months

- Create appraisal input
  - 1 - 2 months

- Readiness Review
- Prepare appraisal plan
  - 1 - 2 months
Rough timeline for a SCAMPI Appraisals

decision to have assessment, select lead assessor

1 - 2 months

create appraisal input

1 - 2 months

Readiness Review
prepare appraisal plan

1 - 2 months

Assessment on-site

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Appraisal process
On-site

Kickoff presentation

Document review (complete)

Interviews

Consolidation and evaluation

Presentation of preliminary results

Complete consolidation, evaluation

Final presentation of results
## Appraisal Requirements for CMMI (ARC)

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<thead>
<tr>
<th>Reliability and correctness of results</th>
<th>Class A</th>
<th>Class B</th>
<th>Class C</th>
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<td>none (SCAMPI C planned)</td>
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