The Software Engineering Institute
and Process Management for
Software Development
El Escorial November, 2004

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University Professor Emeritus
Provost Emeritus
Carnegie Mellon University
Founder, Software Engineering Institute
What I will cover in this presentation

- The Software Engineering Institute
  - Mission, Organization, Technical Programs
  - SEI’s Work Model, Strategy, Vision
- The central role of Process in Software Development
- Simple Improvement Processes
- The Capability Maturity Model® for Software (SW-CMM®)
- ISO/IEC 15504
- CMM Integration (CMMI)
  - CMMI transition status
- What is CMMI
- CMMI Model Representations
- Benefits of CMMI
- Conclusions
Software Engineering Institute

DoD R&D laboratory federally funded research and development center (FFRDC)

Awarded to Carnegie Mellon University in 1984 based on competitive procurement

Sponsored by Office of the Under Secretary of Defense (Acquisition, Technology, & Logistics)

Contract administered by USAF Electronic Systems Center (ESC)

Offices in Arlington, VA, Huntsville AL, Pittsburgh, PA and Frankfurt, Germany

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Federally Funded Research and Development Centers (FFRDC)

- Address complex technical problems of critical importance to sponsors with a breadth and depth of expertise beyond that available inside the government
- Have access, beyond that which is common to the normal contractual relationship, to Government and supplier data, including sensitive and proprietary data, and to employees and facilities
- Conduct business in a manner befitting its special relationship with the Government
- Operate in the public interest with objectivity and independence
- Free from organizational conflicts of interest
- May not compete with the private sector
Mission

The SEI provides technical leadership to advance the practice of software engineering so the DoD can develop, acquire and sustain its software-intensive systems with predictable and improved cost, schedule, and quality.
SEI Organization

Director and CEO
Paul Nielsen

Chief Operating Officer
Clyde Chittister

CREATE
Software Engineering Process Management (SEPM)
Bill Peterson

Networked Survivability Systems Program (NSS)
Rich Pethia

Product Line Systems Program (PLS)
Linda Northrop

Dynamic Systems Program (DS)
Patricia Oberndorf

APPLY
Acquisition Support Program (ASP)
Brian Gallagher

Program Integration Directorate (PID)
Tom Brandt

AMPLIFY
Technology Transition Services Directorate (TTSD)
Sally Cunningham

SEI-Europe GmbH
Geir Fagerhaus

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SEI Technical Program

The right software delivered
defect free, on cost, on time, every time

High-confidence, evolvable, product lines

Integration
Software
Intensive Systems
Performance Critical Systems
Software Architecture Technology

Survivable Systems
(CERT)
Product Line Practice
Predictable Assembly with Certifiable Components

with predictable and improved cost, schedule, and quality

Team Software Process℠
Capability Maturity Model® Integration
Software Engineering Measurement & Analysis

Technical Practice Initiatives
Management Practice Initiatives

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SEI Work Model

helping others improve their software engineering practices

DoD and Community needs

Tech Trends

Identify & Mature Tech

Direct Support

SEI’s experience

Apply

Transition

Amplify

Create

Users’ experience

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SEI Work Model

Areas of Work
- SWE management practices
- SWE technical practices
- Measurement & analysis

Create
Funded by the SEI’s sponsors

Apply
Program Assistance
- Rapid response technical assessments
- Longer-term strategic engagements
Funded by SEI customers

Amplify
Transition
- Training and Licensing
- Publications
- Workshops and conferences
- Affiliates
Funded by the SWE community

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SEI Strategic Themes

- **Predictably better, faster, and cheaper** by -

- **Moving to the left**
  - Embrace a systems engineering approach and make better decisions before coding to predictably improve quality, cost, and schedule.

- **Reusing everything**
  - Reuse code, but also the architecture and knowledge from building similar systems.

- **Never making the same mistake twice**
  - Leverage lessons learned.
**State of Practice Versus SEI’s Vision**

**Software state of practice ("test in" quality)**

- Development
- Integration and System Test

60 - 80% of effort and cost

**World-class developers**

"design in" quality

- *move to the left!*
- *reuse everything*
- *never make the same mistake twice*

*Ref: Standish Group, www.standishgroup.com, 1999*
The SEI Communities

Researchers

Management Process

Software Engineering Technology

SEI

Buyers

Developers

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Vision

Right software delivered defect free, on time, on cost, every time

High-performance teams using best practices

Developers

Buyers

Researchers

Integrated systems and software engineering, but …

Each project is a new invention

An integrated engineering and manufacturing paradigm: systems assembled from certifiable components leveraging commonalities across families of similar systems

Focusing on high-impact challenges (survivability, interoperability, predictability, evolvability, etc.)

Programmed (and reprogrammed) line by line, frequently with unpredictable cost and schedule

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SEI's Strategy (Transition)

Helping others improve their software engineering practices

Amplify
- sustain what is adopted

Apply
- facilitate adoption and use

Create
- documentation and packaging
- analysis of trial use
- identify and mature new practices

Researchers

Partners

Buyers & Developers
The Software Life Cycle

- Starts when application is conceived and ends when it is no longer in use. It includes:
  - Initial concept
  - Requirements analysis
  - Functional design
  - Internal design
  - Documentation planning
  - Test planning
  - Coding
  - Document preparation
  - Integration
  - Testing
  - Maintenance
  - Updates
  - Retesting
  - Phase-out
SEI Strategic Themes

- Predictably better, faster, and cheaper by -
- Moving to the left
  - Embrace a systems engineering approach and make better decisions before coding to predictably improve quality, cost, and schedule.
- Reusing everything
  - Reuse code, but also the architecture and knowledge from building similar systems.
- Never making the same mistake twice
  - Leverage lessons learned.
General Definition of Process

- A process is a set of practices performed to achieve a given purpose; it may include tools, methods, materials, and/or people.
Quality Leverage Points

While process is often described as a leg of the process-people-technology triad, it may also be considered the “glue” that unifies the other aspects.

Everyone realizes the importance of having a motivated, quality work force but even our finest people can’t perform at their best when the process is not understood or operating “at its best.”

Major determinants of product cost, schedule, and quality
Why Focus on Process?

- Process provides a constructive, high-leverage focus...

  - **as opposed to a focus on people**
    - The experience and training of your work force is not always enough.
    - Working harder is not the answer.
    - A well defined process can provide the means to work smarter.
    - Shifts the “blame” for problems from people to the process

  - **as opposed to a focus on technology**
    - Technology, by itself, will most likely not be used effectively.
    - Technology, in the context of an appropriate process roadmap, can provide the most benefit.
The Process Management

Premise

- The quality of a system is highly influenced by the quality of the process used to acquire, develop, and maintain it.

- This premise implies a focus on processes as well as on products.
  - This is a long-established premise in manufacturing.
  - Belief in this premise is visible worldwide in quality movements in manufacturing and service industries (e.g., ISO standards).
Simple Improvement Processes

- Make a plan.
- Execute the plan.
- Learn lessons and do it again.
- Determine where you want to be.

IDEAL<sup>SM</sup>
- Initiating, Diagnosing, Establishing, Acting & Learning
The IDEAL℠ Model

SM IDEAL is a service mark of Carnegie Mellon University.

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The Capability Maturity Model® for Software (SW-CMM®)

A common-sense application of the concepts of Total Quality Management to software projects
A community-developed guide with descriptions of good engineering and management practices
A five-level prescriptive model for organizational transformation
The basis for reliable and consistent CMM-based appraisals

## Software CMM v1.1

<table>
<thead>
<tr>
<th>Level</th>
<th>Focus</th>
<th>Key Process Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Managed</td>
<td>Product and process quality</td>
<td>Organization Process Focus Organization Process Definition Training Program Integrated Software Management Software Product Engineering Intergroup Coordination Peer Reviews</td>
</tr>
<tr>
<td>3 Defined</td>
<td>Engineering processes and organizational support</td>
<td>Requirements Management Software Project Planning Software Project Tracking &amp; Oversight Software Subcontract Management Software Quality Assurance Software Configuration Management</td>
</tr>
<tr>
<td>2 Repeatable</td>
<td>Project management processes</td>
<td></td>
</tr>
<tr>
<td>1 Initial</td>
<td>Competent people (and heroics)</td>
<td></td>
</tr>
</tbody>
</table>
ISO/IEC 15504
(Software Engineering – Process Assessment)

- Continuous representation
  - processes (purpose + outcomes)
  - capability dimension (six levels)
- Process Reference Models
  - ISO/IEC 12207 (Software Life Cycle Processes)
  - ISO/IEC 15288 (Systems Life Cycle Processes)
- Process Assessment Models
  - ISO/IEC 15504-5 exemplar (under development)

Improvement and Impacts

Improvement per level
- Quality (reliability, defects) improves by roughly a factor of 2 (or more)
- Effort for a given product decreases 15-21%, productivity increases, cycle time decreases

Impact of Software CMM and ISO 9001
- Certified firms indicate better product attributes and return on quality than non-certified firms
- CMM highly rated firms (levels 4 and 5) are better than ISO 9001 certified firms with respect to product attributes and return on quality

CMM Integration (CMMI)

- The Software CMM is being superseded by CMMI.

- CMMI addresses
  - systems engineering
  - software engineering
  - integrated product and process development
  - sourcing selection
  - acquisition module for government acquisition organizations

- [http://www.sei.cmu.edu/cmmi/](http://www.sei.cmu.edu/cmmi/)
Process Improvement Involves Dealing with Multiple Dimensions at One Time

CMMI based improvement is Much More than simply asking people to use a different template.
## CMM Integration (CMMI-SE/SW/IPPD/SS v1.1)

<table>
<thead>
<tr>
<th>Level</th>
<th>Process Characteristics</th>
<th>Process Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimizing 5</td>
<td>Focus is on quantitative continuous process improvement</td>
<td>Causal Analysis and Resolution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organizational Innovation and Deployment</td>
</tr>
<tr>
<td>Quantitatively Managed 4</td>
<td>Process is measured and controlled</td>
<td>Quantitative Project Management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organizational Process Performance</td>
</tr>
<tr>
<td>Defined 3</td>
<td>Process is characterized for the organization and is proactive</td>
<td>Requirements Development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technical Solution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Product Integration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Verification</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organizational Process Focus Integrated Project Management</td>
</tr>
<tr>
<td>Managed 2</td>
<td>Process is characterized for projects and is often reactive</td>
<td>Requirements Management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project Planning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project Monitoring and Control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supplier Agreement Management</td>
</tr>
<tr>
<td>Initial 1</td>
<td>Process is unpredictable, poorly controlled, and reactive</td>
<td>Configuration Management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Measurement and Analysis</td>
</tr>
</tbody>
</table>

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Documented Results of CMM-based PI

- Process improvement benefits fall into one or more of these general categories:
  - improved schedule and budget predictability
  - reduction of rework
  - improved cycle time
  - increased productivity
  - improved quality (as measured by defects)
  - increased customer satisfaction
  - improved employee morale
  - increased return on investment
  - decreased cost of quality

- All this is in addition to meeting your customer’s requirement....
CMMI Transition Status

- 234 Introduction to CMMI instructors trained
- 402 SCAMPI Lead Appraisers trained
- 830 students trained in Intermediate Concepts of CMMI
- 179 Introduction to CMMI instructors authorized
- 16,161 students trained in Introduction in CMMI
- 293 SCAMPI Lead Appraisers authorized
- 80 active transition partners that offer Introduction to CMMI training
- 147 active transition partners that offer SCAMPI appraisal services
Number of Appraisals Conducted by Year
Reported as of 2 March 2004

- SPA
- SEI CBA IPI
- SCAMPI vX

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What is CMMI?

- CMMI
  - is not a process; does not tell you How to do your work
  - is a model of best practices in systems and software development and in product development
  - does tell you What to do
  - is based on the process management premise
An organization may choose an approach to process improvement from either of the following:

- process area capability
- organizational maturity

CMMI models support each approach with a representation.

- process area capability - continuous representation
- organizational maturity - staged representation
Some benefits of choosing the continuous representation are

- It allows you to select the order of improvement that best meets your organization’s business objectives and mitigates your organization’s areas of risk.
- It enables comparisons across and among organizations on a process area by process area basis.
- It provides an easy migration from EIA/IS-731 to CMMI.
<table>
<thead>
<tr>
<th>Category</th>
<th>Process Areas</th>
</tr>
</thead>
</table>
| Process       | Organizational Process Focus  
| Management    | Organizational Process Definition  
|               | Organizational Training  
|               | Organizational Process Performance  
|               | Organizational Innovation and Deployment |
| Project       | Project Planning  
| Management    | Project Monitoring and Control  
|               | Supplier Agreement Management  
|               | Integrated Project Management for IPPD  
|               | Risk Management  
|               | Integrated Teaming  
|               | Integrated Supplier Management  
|               | Quantitative Project Management |
| Engineering   | Requirements Management  
|               | Requirements Development  
|               | Technical Solution  
|               | Product Integration  
|               | Verification  
|               | Validation |
| Support       | Configuration Management  
|               | Process and Product Quality Assurance  
|               | Measurement and Analysis  
|               | Decision Analysis and Resolution  
|               | Organizational Environment for Integration  
|               | Causal Analysis and Resolution |
Capability Levels

- **Capability levels**, used in the continuous representation, describe a sequential order for approaching process improvement within each process area.

- Capability levels build on each other, providing a recommended order for approaching process improvement within a selected process area.

- Capability levels enable you to track, evaluate, and demonstrate your organization’s progress as you improve processes associated with a process area.
Staged Representation

Some benefits of choosing the staged representation are

• It provides a proven sequence of improvements, each serving as a foundation for the next.
• It permits comparisons across and among organizations by the use of maturity levels.
• It provides an easy migration from the SW-CMM to CMMI.
• It provides a single rating that summarizes appraisal results and allows comparisons among organizations.
<table>
<thead>
<tr>
<th>Level</th>
<th>Focus</th>
<th>Process Areas for SE/SW/IPPD/SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Optimizing</td>
<td>Continuous Process Improvement</td>
<td>Organizational Innovation and Deployment  &lt;br&gt;Causal Analysis and Resolution</td>
</tr>
<tr>
<td>4 Quantitatively Managed</td>
<td>Quantitative Management</td>
<td>Organizational Process Performance  &lt;br&gt;Quantitative Project Management</td>
</tr>
<tr>
<td>3 Defined</td>
<td>Process Standardization</td>
<td>Requirements Development  &lt;br&gt;Technical Solution  &lt;br&gt;Product Integration  &lt;br&gt;Verification  &lt;br&gt;Validation  &lt;br&gt;Organizational Process Focus  &lt;br&gt;Organizational Process Definition  &lt;br&gt;Organizational Training  &lt;br&gt;Integrated Project Management for IPPD  &lt;br&gt;Risk Management  &lt;br&gt;Integrated Teaming  &lt;br&gt;Integrated Supplier Management  &lt;br&gt;Decision Analysis and Resolution  &lt;br&gt;Organizational Environment for Integration</td>
</tr>
<tr>
<td>2 Managed</td>
<td>Basic Project Management</td>
<td>Requirements Management  &lt;br&gt;Project Planning  &lt;br&gt;Project Monitoring and Control  &lt;br&gt;Supplier Agreement Management  &lt;br&gt;Measurement and Analysis  &lt;br&gt;Process and Product Quality Assurance  &lt;br&gt;Configuration Management</td>
</tr>
<tr>
<td>1 Initial</td>
<td></td>
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</tbody>
</table>
Maturity Levels

- **Maturity levels**, used in the staged representation, organize selected process areas into five evolutionary plateaus to support and guide process improvement across the organization.

- **Maturity levels** are defined evolutionary plateaus of process improvement, in which each level is supported by the characteristics of the process areas implemented within the lower levels.

- **Maturity levels** represent a process improvement evolution for the entire organization.
Maturity Levels

1. Process unpredictable, poorly controlled and reactive
2. Process characterized for projects and is often reactive
3. Process characterized for the organization and is proactive
4. Process measured and statistically controlled
5. Focus on continuous improvement

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Continuous

...for a single process area or a set of process areas

Staged

...for a specified set of process areas across an organization

Process Area Capability

CL0  CL1  CL2  CL3  CL4  CL5

PA  PA  PA

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Comparing the Different Representations

- Both representations provide ways of implementing process improvement to achieve business goals.

- Both representations provide essentially the same content but are organized in different ways.

- There is nothing that requires that you use one or the other representation – you can use them both concurrently if that suits your business needs.
Representation Synergy

- The continuous representation provides additional *de facto* granularity in support of a staged-focus initiative:
  - as a guide for detailed *tactical planning*
  - to demonstrate *intermediate progress* short of process area or maturity level
  - to *allay concerns* and build support among stakeholders

- The staged representation can provide structure for a continuous-focus initiative:
  - as a guide for *big picture* “strategic” planning
  - to “chunk” higher-granularity activities for senior management
  - as a means for representing *high-level success* in “industry standard” terms key stakeholders will more readily understand
Benefits of CMMI

- CMMI provides
  - Efficient, effective assessment and improvement across multiple process disciplines in an organization
  - Improvements to best practices incorporated from the Software CMM
  - A common, integrated vision of improvement for all elements of an organization
  - A means of representing new discipline-specific information in a standard, proven process-improvement context
Conclusions

- The Software Engineering Institute at Carnegie Mellon has met its Vision and fulfilled its Mission as an FFRDC.
- The SEI has made an impact in a number of technical programs transitioned to the DoD and Industry.
- From the beginning the SEI placed great emphasis in the improvement of the Software Process and its Management.
- Among the flagships of the SEI are CMM and its successor CMMI.
- Certified firms indicate better product attributes and return on quality than non-certified firms.
Questions?
Comments?