1987 U.S. Department of Defense task force:
- The fundamental problem with software is that the software process is badly managed

DoD initiative:
- Software Engineering Institute (SEI) at Carnegie Mellon University

Software process improvement initiatives
- Capability maturity model (CMM) at SEI (http://www.sei.cmu.edu/)
- ISO 9000-series
- ISO/IEC 15504

Capability Maturity Models
- Not life-cycle models
- Rather, a set of strategies for improving the software process
  - SW–CMM for software
  - P–CMM for human resources ("people")
  - SE–CMM for systems engineering
  - IPD–CMM for integrated product development
  - SA–CMM for software acquisition
- These strategies are unified into CMMI (capability maturity model integration)

SW–CMM
- A strategy for improving the software process incrementally
- Put forward in 1986 by the SEI
- Fundamental ideas:
  - Improved management leads to improved process techniques
  - Improving the software process leads to improved software quality
    - Delivery on time, within budget
    - Not the other way around

SW–CMM (2)
- Five levels of maturity are defined
  - Maturity is a measure of the goodness of the process itself
  - An organization advances stepwise from level to level

Level 1: Initial Level
- Ad hoc approach
  - The entire process is unpredictable
  - Management consists of responses to crises
    - Depends entirely on the current staff
  - Most organizations world-wide are at level 1
Level 2: Repeatable Level
- Basic software management
  - Management decisions should be made on the basis of previous experience with similar products
  - Measurements ("metrics") are made, e.g., costs and schedules
  - These can be used for making cost and duration predictions in the next project
  - Problems are identified, immediate corrective action is taken

Level 3: Defined Level
- The software process is fully documented
  - Managerial and technical aspects are clearly defined
  - Continual efforts are made to improve quality and productivity
  - Reviews are performed to improve software quality
  - CASE environments are applicable now (and not at levels 1 or 2)

Level 4: Managed Level
- Quality and productivity goals are set for each project
  - Quality and productivity are continually monitored
  - Statistical quality controls are in place

Level 5: Optimizing Level
- Continuous process improvement
  - Statistical quality and process controls
  - Feedback of knowledge from each project to the next

Key Process Areas
- There are key process areas (KPAs) for each level
- For example, Level-2 KPAs include:
  - Requirements management
  - Project planning
  - Project tracking
  - Configuration management
  - Quality assurance

Key Process Areas Summary (Figure 3.3)
- Compare
  - Level 2: Detection and correction of faults
  - Level 5: Prevention of faults
Experiences with SW–CMM

- It takes:
  - 3 to 5 years to get from level 1 to level 2
  - 1.5 to 3 years from level 2 to level 3
  - SEI questionnaires highlight shortcomings of current process, suggest ways to improve the process

Goals

- Original goal of CMM:
  - Defense contracts would be awarded only to capable firms
- The U.S. Air Force stipulated that every Air Force contractor had to attain SW–CMM level 3 by 1998
  - The DoD subsequently issued a similar directive
- The CMM has now gone far beyond the limited goal of improving DoD software

Other Software Process Improvement Initiatives

- Other software process improvement (SPI) initiatives include:
  - ISO 9000-series
  - ISO/IEC 15504
- Non-management initiatives
  - Personal Software Process (PSP)
  - Team Software Process (TSP)

ISO 9000

- A set of five standards for industrial activities
  - ISO 9001 for quality systems
  - ISO 9000-3, guidelines to apply ISO 9001 to software
  - There is an overlap with CMM, but they are not identical
  - Not process improvement

ISO 9000 (2)

- There is a stress on documenting the process
- There is an emphasis on measurement and metrics
- ISO 9000 is required to do business with the EU
- Also required by many U.S. businesses, including GE
- More and more U.S. businesses are ISO 9000 certified

ISO/IEC 15504

- Original name: Software Process Improvement Capability dEtermination (SPICE)
- International process improvement initiative
- Started by the British Ministry of Defence (MOD)
- Includes process improvement, software procurement
ISO/IEC 15504 (2)

- Extends and improves CMM, ISO 9000
- A framework, not a method
  - CMM, ISO 9000 conform to this framework
- Now referred to as ISO/IEC 15504
- Or just 15504 for short

Costs and Benefits of Software Process Improvement

- Hughes Aircraft (Fullerton, CA) spent $500K (1987–90)
  - Savings: $2M per year, moving from level 2 to level 3
- Raytheon moved from level 1 in 1988 to level 3 in 1993
  - Productivity doubled
  - Return of $7.70 per dollar invested in process improvement

Costs and Benefits of Software Process Improvement (2)

- Tata Consultancy Services (India) used ISO 9000 and CMM (1996–90)
  - Errors in estimation decreased from 50% to 15%
  - Effectiveness of reviews increased from 40% to 80%

Costs and Benefits of Software Process Improvement (3)

- Motorola Government Electronics Division has used CMM (1992–97)

<table>
<thead>
<tr>
<th>CMM Level</th>
<th>Number of Projects</th>
<th>Relative decrease in duration</th>
<th>Faults per MEASL detected</th>
<th>Relative productivity</th>
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</thead>
<tbody>
<tr>
<td>Level 1</td>
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<td>1.0</td>
<td>---</td>
<td>---</td>
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<tr>
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<td>3.2</td>
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<tr>
<td>Level 5</td>
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<td>7.8</td>
<td>126</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Results of 34 Motorola Projects

- MEASL – Million equivalent assembler source lines
- Motorola does not reveal productivity data
  - Productivity is measured relative to that of a selected level-2 project
  - No fault or productivity data available for level-1 projects (by definition)

Costs and Benefits of Software Process Improvement (4)

- There is interplay between
  - Software engineering standards organizations
  - Software process improvement initiatives
- ISO/IEC 12207 (1995) is a full life-cycle software standard
  - In 1998, the U.S. version (IEEE/EIA 12207) was published that incorporated ideas from CMM
  - ISO 9000-3 now incorporates part of ISO/IEC 12207
Non-Management Processes

- CMM is for the management of software process – “what” to do
- SEI also developed processes for the individual software engineer and for teams of software engineers – “how” to do it
  - Personal Software Process (PSP)
  - Team Software Process (TSP)

Personal Software Process

- Goal is to show how individuals should perform their tasks in an effective and professional way
- Use process principles at the individual level
- Hard to make people change
  - Training workshop with all members of a group

Personal Software Process (2)

- PSP0: Current process & basic measures
  - Coding standard
  - Process improvement
  - Proposal size
  - Measurement
- PSP1: Size estimating & test report
  - Task planning
  - Schedule planning
- PSP2: Code reviews & design reviews
  - Design templates
- PSP3: Cyclic development

Personal Software Process (3)

- Results generally show software engineers making better estimates of time and finishing with fewer faults
- Must be sustained with management support
- Need to integrate individual processes into a team

Team Software Process

- Shows software engineers how to build a self-directed team and how to perform as an effective team member
- Shows management how to guide and support these teams and how to maintain an environment that fosters high team performance

Team Software Process (2)

- The TSP has five objectives:
  - Build self-directed teams that plan and track their work, establish goals, and own their processes and plans.
  - Show managers how to coach and motivate their teams and how to help them sustain peak performance.
Team Software Process (3)

- Accelerate software process improvement by making CMM Level 5 behavior normal and expected.
- Provide improvement guidance to high-maturity organizations.
- Facilitate university teaching of industrial-grade team skills.

Team Software Process (4)

- Uses scripts, forms, and standards to describe what team members should do.
- Each phase is (re)launched with a process that produces individual and merged plans and processes.
- Similar results as PSP on integration and acceptance testing faults.
- Also allows teams to resist unreasonable schedules with concrete data.

References

  - Part II: The Personal Process, March 1998
  - Part III: The Team Process, April 1998
- Links available at URL 
  http://www.sei.cmu.edu/tsp/publications/index.html#fitin