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Software Quality

Chapter 5

Process Quality

5.1 About Process Quality

5.2 CMMI

5.3 CMMI process appraisal

5.4 SPICE / ISO 15504

Product quality vs. process quality

- Hypothesis: Process quality positively influences product quality
- Define processes systematically
  - Standardization of working style and habits
  - Less dependence on capable individual persons
  - Makes success repeatable
  - Makes quality controllable
- Improve existing processes systematically
  - Adapt to a changing world
  - Adapt to new insights
  - Avoid making mistakes twice

A means, not an end

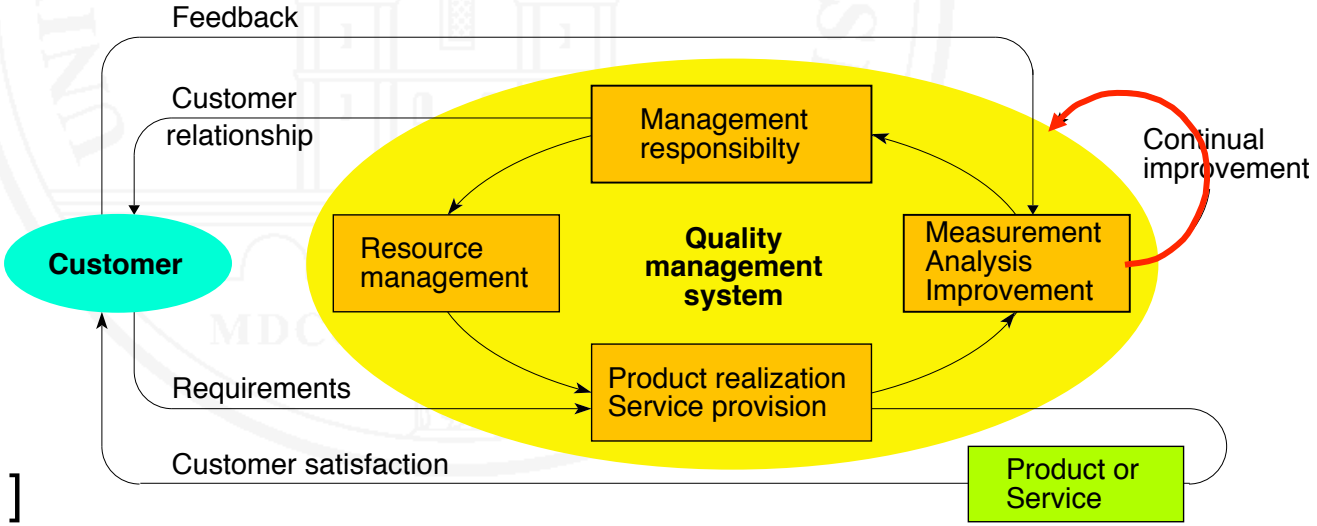
- Process quality is not an end in itself
- The real goal is product quality
- Avoid three major threats [Glinz 1999]:
  - Process bureaucracy
  - Process solidification
  - Confusing the process (i.e., a model) with the reality it models

Defining processes

- Explicit descriptions for every process
- Codify current best practices of organization
- Independent of individuals involved in the process (describes roles only)
- Every process has an owner who is responsible for the process definition

Process improvement

- Software process improvement – Meta process for changing the software processes of an organization; typically on the basis of regular process assessments
- Ultimate goal: improve not only process quality, but primarily product quality

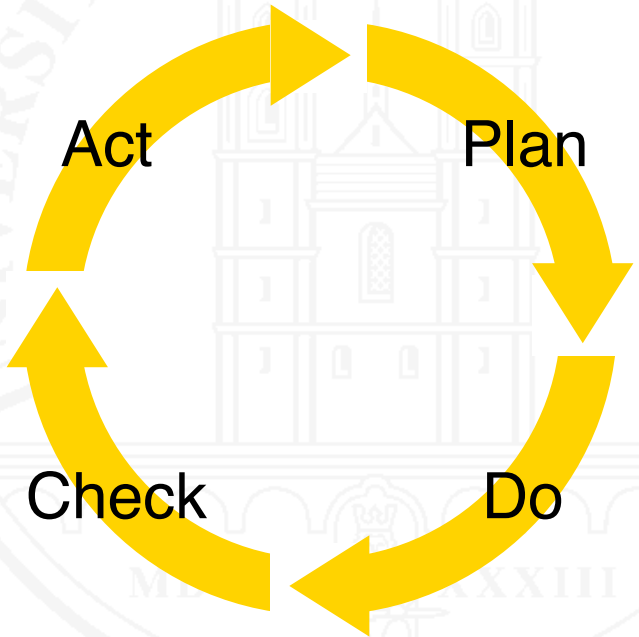


[cf. Chapter 1]

The metaprocess for process improvement

The Deming cycle: Plan-Do-Check-Act (Deming 1986)

- Adapt
- Eliminate weaknesses
- Automate



- Design
- Document

- Measure
- Analyze
- Control

- Train
- Institutionalize
- Perform

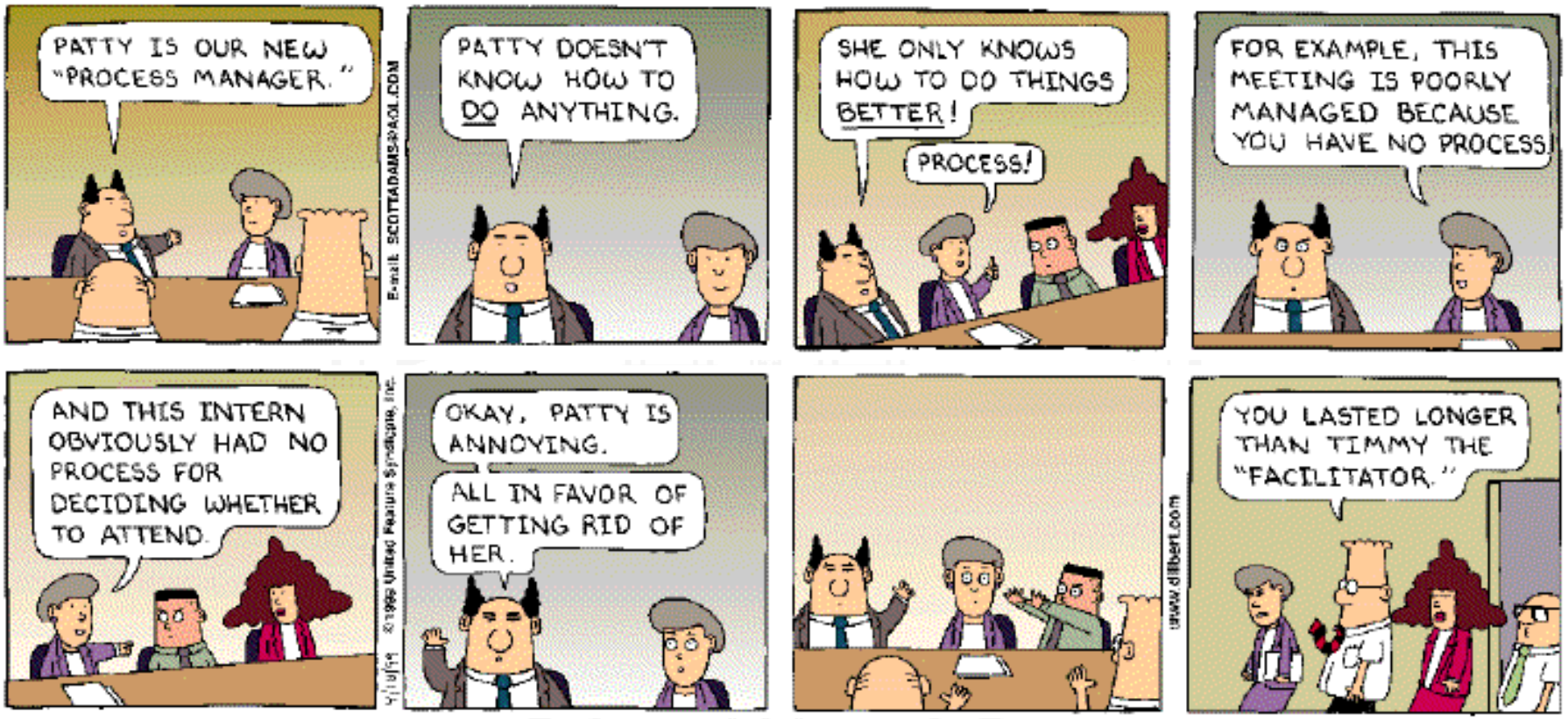
[cf. Chapter 1]

It's not just about changing processes

- Process improvement is not just about changing processes e.g.
  - Process descriptions
  - Work procedures

- It's about changing people
  - Habits
  - Beliefs
  - Organizational structure

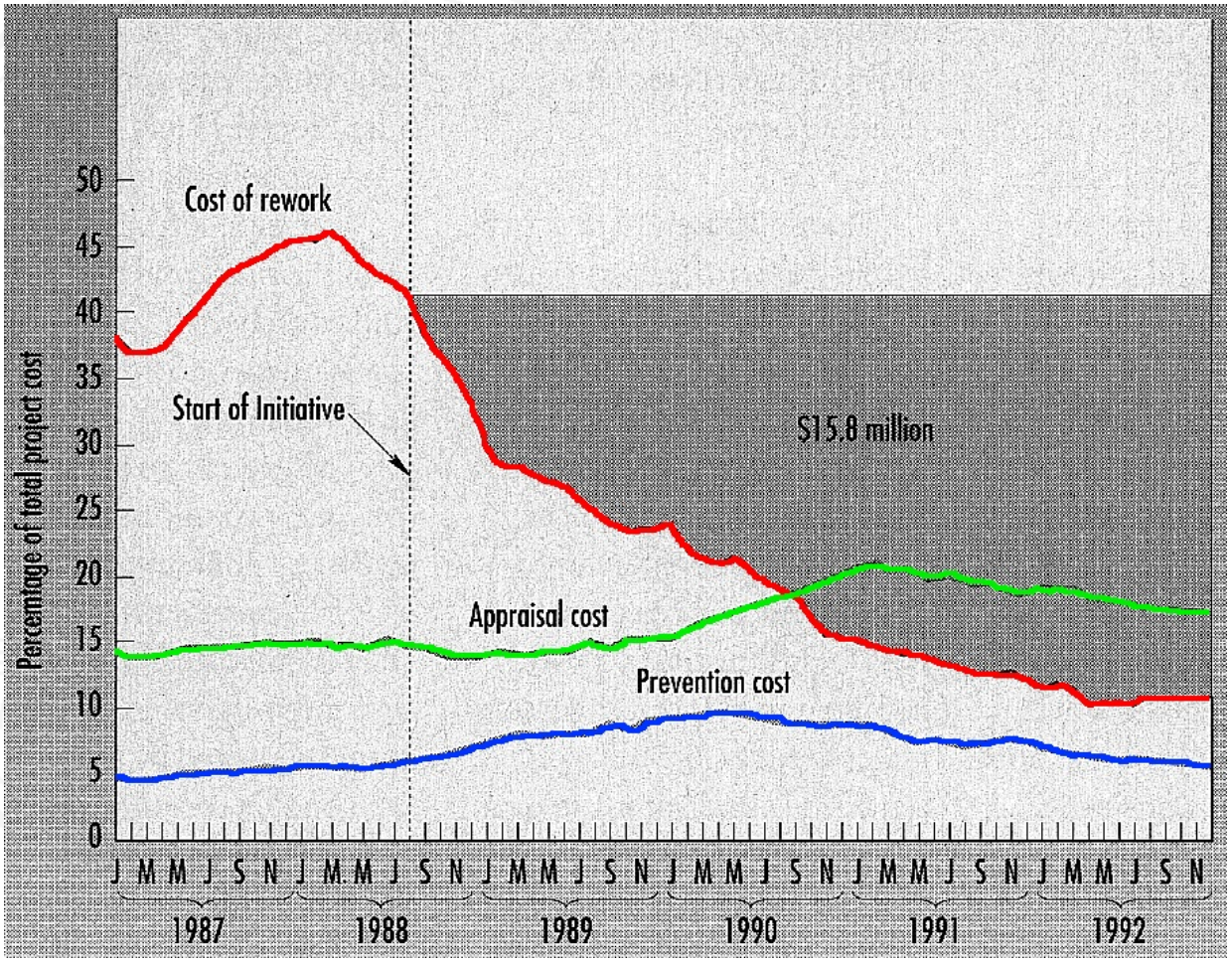
Problems of process improvement illustrated



What to improve?

For example:

- Optimize flows of materials and information
- Reduce cost induced by errors (Dion 1993)



5.1 About Process Quality

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History and background: the roots of CMMI

- Systematic process improvement (Deming 1986)
- Process-oriented software development (Humphrey 1989)
- Demand for assessing software suppliers with respect to the maturity of their software development processes
- Process maturity models
  - CMM – Capability Maturity Model (Paulk et al. 1993)
  - SPICE – Software Process Improvement and Capability dEtermination (ISO/IEC 15504)
  - Bootstrap (EU-Esprit project; one of the roots of SPICE)

CMM (Capability Maturity Model)

- The US Department of Defense (DoD) had a problem: how to assess the capabilities of its software suppliers
  - DoD tasked SEI (Software Engineering Institute, a DoD-sponsored institution affiliated with Carnegie Mellon University) to develop a capability assessment method
  - SEI developed CMM, first released in 1991
- CMM assesses capabilities in key process areas (KPAs) by analyzing/auditing key practices within the KPAs
- Results in an overall maturity level on an ordinal scale with five values:
  Initial, Repeatable, Defined, Managed, Optimizing

CMM (Capability Maturity Model) – 2

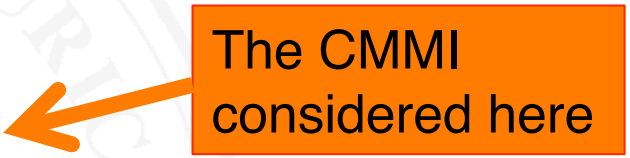
- Soon became very popular
- Nevertheless had major shortcomings (Bollinger und McGowan, 1991)
- CMM variants appeared: for systems engineering, people, integrated product development, acquisition,...
- Demand for a comprehensive, tailorable capability assessment framework
  - ➥ CMMI (Capability Maturity Model Integration)

CMMI – Goals

- Integrated capability / maturity assessment framework
- Integrates three major CMM variants
  - CMM for Software Development (the original CMM of 1991)
  - CMM for Systems Engineering
  - CMM for Integrated development
- Replaced CMM and all its variants
- Unifies elements from CMM and from SPICE
- Is tailorable

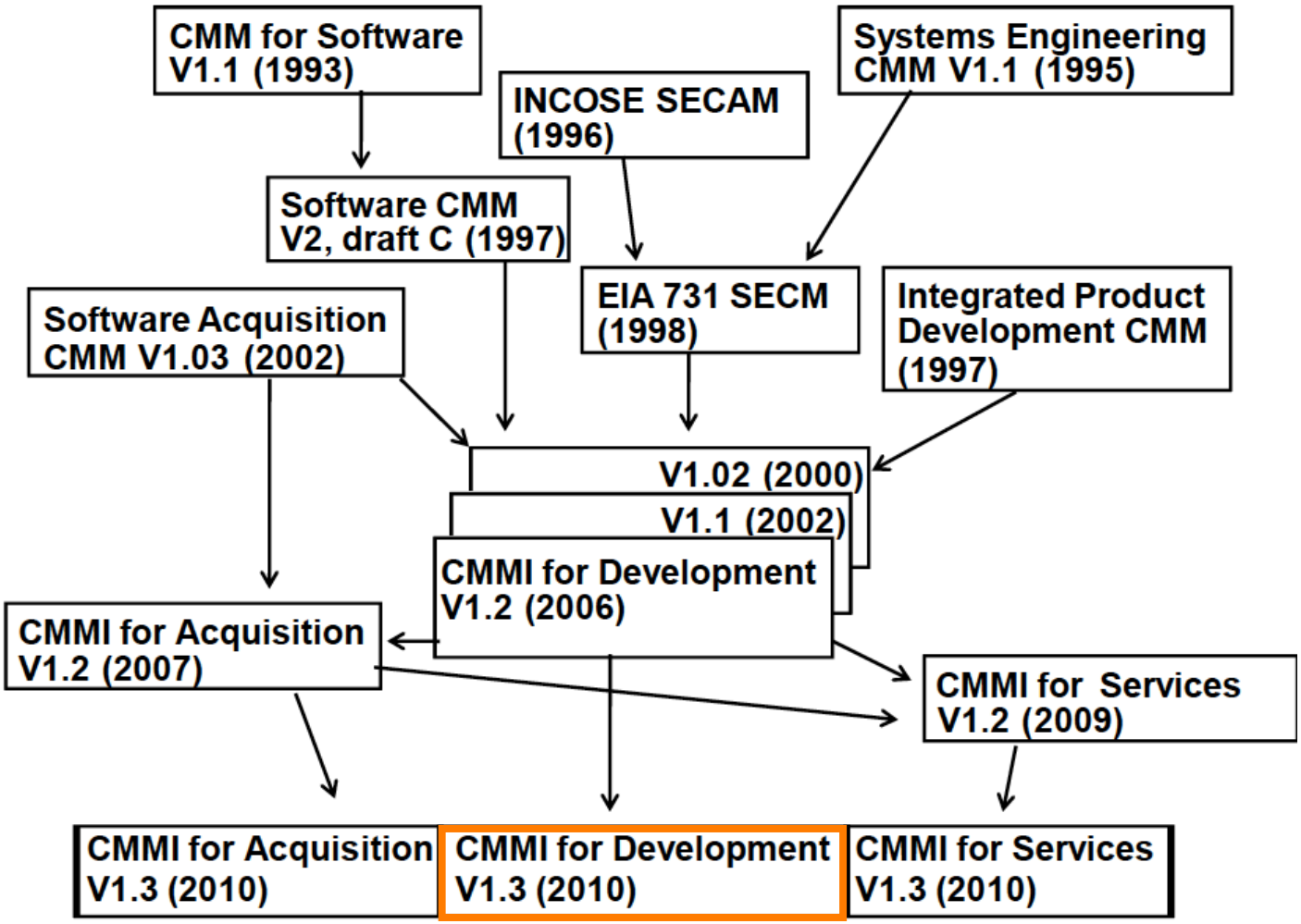
CMMI – Actual

- The goals of full integration and tailorability have not been achieved
- Today we have
  - CMMI-DEV: CMMI for development
  - CMMI-ACQ: CMMI for acquisition
  - CMMI-SVC: CMMI for services
  - People CMM



History of CMMI-DEV

Source: CMMI Product Team (2010)



Key elements of CMMI

- Two representations for results:
  - Staged (analogous to CMM-SW)
  - Continuous (more modern, based on SPICE)
- Based on examining up to 22 process areas (PA)
- Assessing to what extent the goals and practices defined for a PA are met

The process areas (PA)

- 22 process areas to be assessed
- For every process area, we have
  - Specific goals that have to be achieved
  - Specific practices for achieving the goals
- CMMI can be tailored to specific domains by omitting those process areas that are irrelevant for those domains

Overview of the CMMI process areas

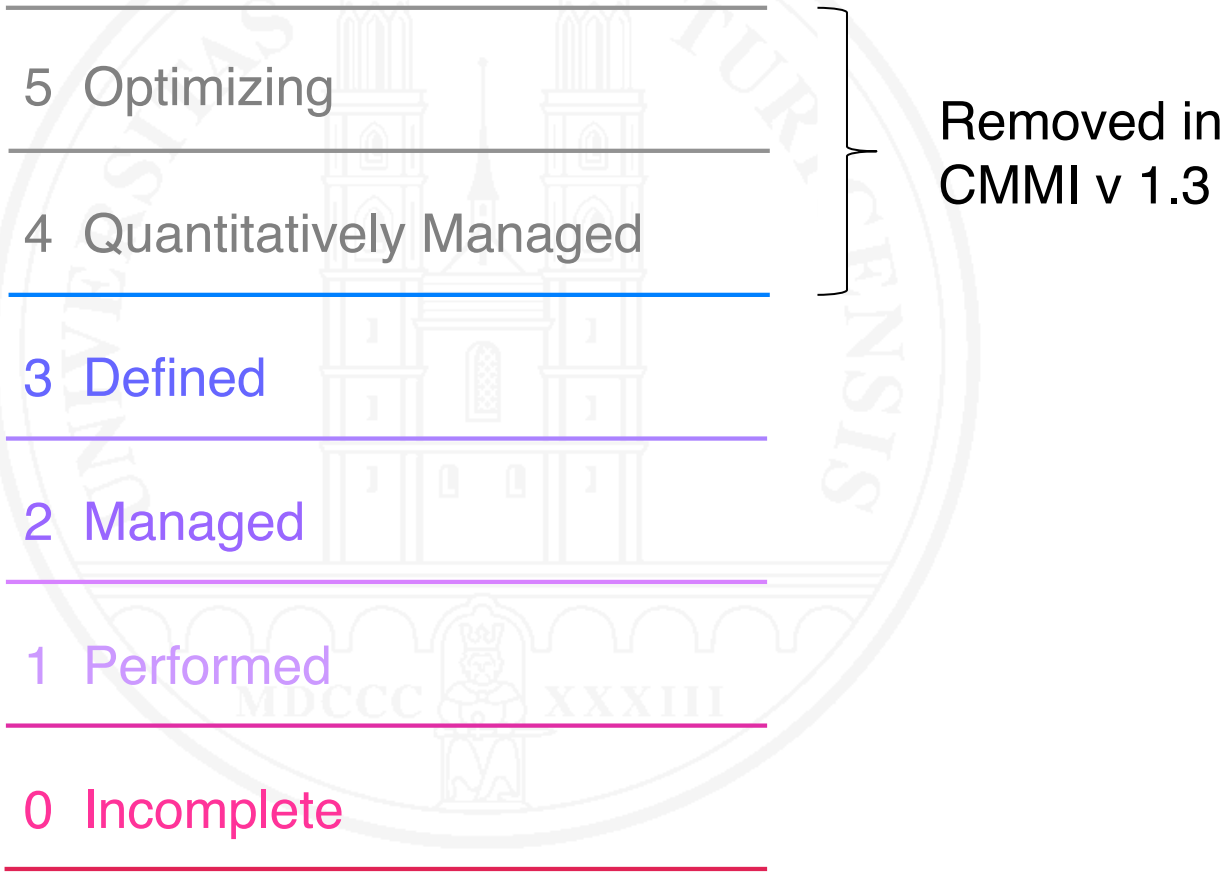
CAR	Causal Analysis and Resolution
CM	Configuration Management
DAR	Decision Analysis and Resolution
IPM	Integrated Project Management
MA	Measurement and Analysis
OPD	Organizational Process Definition
OPF	Organizational Process Focus
OPM	Organizational Performance Management
OPP	Organizational Process Performance
OT	Organizational Training
PI	Product Integration
PMC	Project Monitoring and Control
PP	Project Planning
PPQA	Process and Product Quality Assurance
QPM	Quantitative Project Management
RD	Requirements Development
REQM	Requirements Management
RSKM	Risk Management
SAM	Supplier Agreement Management
TS	Technical Solution
VAL	Validation
VER	Verification

Staged vs. continuous representation

- Continuous Representation
  - Every process area is assessed individually, using a scale of four capability levels
  - Result: capability profile over all PAs
  - Corresponds to the SPICE assessment model
- Staged Representation
  - Five maturity levels; correspond to capability levels 1-5
  - Maturity level determined by assessing which PAs achieve which capability levels
  - Result: number between 1 and 5
  - Corresponds to the CMM assessment model

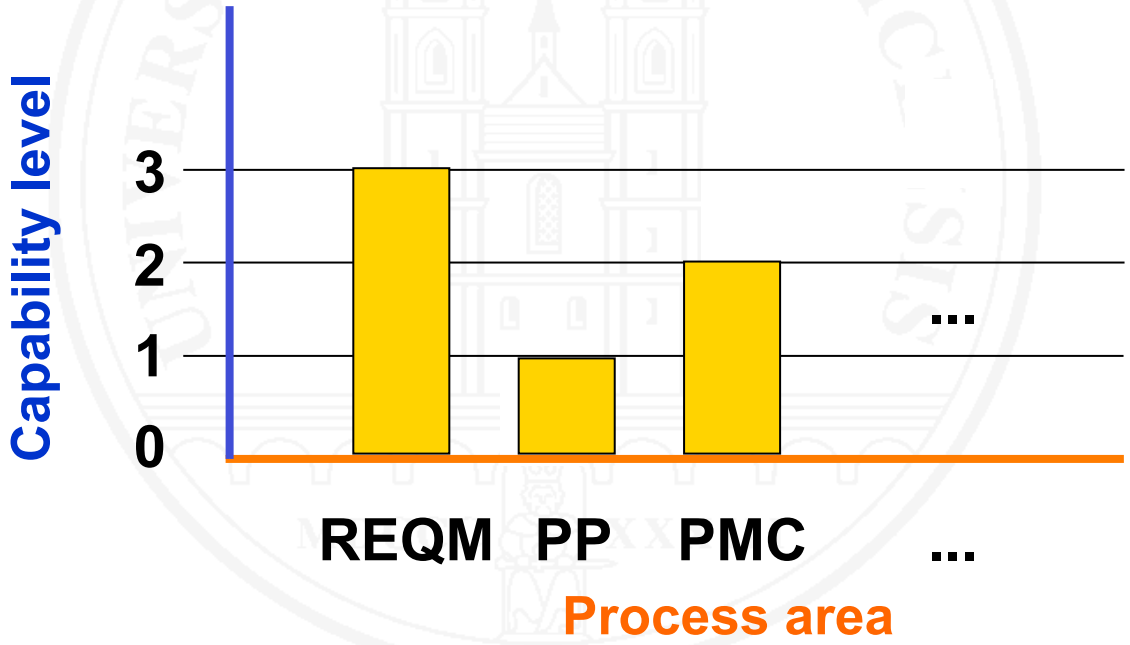
CMMI capability levels

- Every process area is assessed on a four-level scale:



Capability profile

Assessment of all process areas results in a capability profile:



Classification of process areas

Maturity level (staged re-presentation)	Process group (continuous representation)			
	Project management	Support	Engineering	Process management
5 Optimizing		CAR		OPM
4 Quantitativ-ely managed	QPM			OPP
3 Defined	IPM RSKM	DAR	PI RD TS VAL VER	OPD OPF OT
2 Managed	PMC PP SAM	CM MA PPQA	REQM	

Determining capability levels

- The capability levels are characterized by
  - Generic goals, which have to be achieved through
  - Generic practices
- If the processes of an organization don't cover a process area completely, this process area is assigned a capability level of zero (Incomplete)
- The capability level of a fully covered process area is determined by assessing how well the processes and practices of the organization under study meet the generic goals and practices for that level (including those for all lower levels)

Capability level 1: Performed

Generic goal:

GG 1 Achieve specific goals (of the process area under study)

Generic practices:

GP 1.1 Perform specific practices (of the process area under study)

Capability level 2: Managed

Generic goal:

GG 2 Institutionalize a managed process

Capability level 2: Managed (continued)

Generic practices:

GP 2.1	Establish an organizational policy
GP 2.2	Plan the process
GP 2.3	Provide resources
GP 2.4	Assign responsibility
GP 2.5	Train people
GP 2.6	Control work products
GP 2.7	Identify and involve relevant stakeholders
GP 2.8	Monitor and control the process
GP 2.9	Objectively evaluate adherence
GP 2.10	Review status with higher level management

Capability level 3: Defined

Generic goal:

GG 3 Institutionalize a defined process

Generic practices:

GP 3.1 Establish a defined process

GP 3.2 Collect process related experiences

Example: PA Requirements Development (RD)

Specific goals and practices:

SG 1 Develop customer requirements

- SP 1.1 Elicit needs
- SP 1.2 Transform stakeholder needs into customer requirements

SG 2 Develop product requirements

- SP 2.1 Establish product and product component requirements
- SP 2.2 Allocate product component requirements
- SP 2.3 Identify interface requirements

Example (continued)

SG 3 Analyze and Validate Requirements

- SP 3.1 Establish Operational Concepts and Scenarios
- SP 3.2 Establish a Definition of Required Functionality and Quality Attributes
- SP 3.3 Analyze Requirements
- SP 3.4 Analyze Requirements to Achieve Balance
- SP 3.5 Validate Requirements

Example (continued)

Additionally, also all generic goals and practices – adapted to requirements development – must be met

For example, in process area Requirements Development:

- To meet GP 2.6: Control work products, the following items should be placed under control:
  - Customer functional and quality attribute requirements
  - Definition of required functionality and quality attributes
  - Product and product component requirements
  - Interface requirements

Determining the maturity level

- Maturity level 2 (Managed)

  The following process areas all need to be at least on capability level 2:

  - CM Configuration Management
  - MA Measurement and Analysis
  - PMC Project Monitoring and Control
  - PP Project Planning
  - PPQA Process and Product Quality Assurance
  - REQM Requirements Management
  - SAM Supplier Agreement Management

Determining the maturity level – 2

- Maturity level 3 (Defined)

  The following process areas all need to be on capability level 3:

  All process areas, except

  - CAR Causal Analysis and Resolution
  - OPM Organizational Performance Management
  - OPP Organizational Process Performance
  - QPM Quantitative Project Management

Determining the maturity level – 3

- Maturity level 4 (Quantitatively managed)

  The following process areas all need to be on capability level 3:

  All process areas, except
  - CAR Causal Analysis and Resolution
  - OPM Organizational Performance Management

- Maturity level 5 (Optimizing)

  All process areas need to be on capability level 3

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Process assessment (appraisal) with CMMI

- CMMI provides a framework for both
  - Process assessment (appraisal in CMMI terminology)
  - Process improvement
- Assessment method
  - No prescribed method, but
  - Requirements that an appraisal method must meet: ARC (Appraisal Requirements for CMMI; CMU/SEI-2011-TR-006)
  - SEI has its own, ARC-compliant method: SCAMPI (Standard CMMI Appraisal Method for Process Improvement, CMU/SEI-2011-HB-001)

Goals of an appraisal

- In the framework of process improvement
  - Determine the current state
  - Identify opportunities for improvement
  - Checking the effectiveness of improvement measures
- Assuring the process quality of an organization towards its customers or suppliers
- When a customer demands it as a prerequisite for placing an order

Appraisal classes

- ARC defines three appraisal classes for CMMI :

Requirements	Class A	Class B	Class C
Types of Objective Evidence Gathered	Documents and interviews	Documents and interviews	Documents or interviews
Ratings Generated	Goal ratings required	Not allowed	Not allowed
Organizational Unit Coverage	Required	Not required	Not required
Minimum Team Size	4	2	1
Appraisal Team Leader Requirements	Lead appraiser	Person trained and experienced	Person trained and experienced

- Class A: Formal appraisal by certified external experts
- Classes B or C: Typically for internal and informal appraisals

Steps of a CMMI appraisal

- Decide about appraisal class (type A, B, or C)
- Determine the organizational unit(s) to be assessed
- Select appraisal method: SCAMPI or another ARC-compliant method
- Select representation: staged or continuous
- Map the organization's processes to CMMI process areas
- Commission appraiser(s) to perform the appraisal
- Perform appraisal
- Discuss results, derive follow-up measures

CMMI appraisal: tasks of appraisers

- Derive a questionnaire from CMMI documentation
- Collect evidence
  - Inspect documents
  - Conduct interviews
- Compare actual evidence with required goals and practices for the process areas under assessment
- Derive capability levels for assessed process areas → capability profile
- In staged representation: determine the maturity level
- Discuss results, make suggestions for improvement

Process improvement with CMMI

- Determine current state with an ARC compliant appraisal
- Analyze capability profile
- Decide about profile to be achieved in the next improvement step
- Derive improvement measures for process areas to be improved
- Implement and institutionalize new or changed processes
- Check the success with another appraisal

Reading assignment

Download the CMMI-DEV V 1.3 technical report [http://www.sei.cmu.edu/reports/10tr033.pdf]

- Browse part one
- Read Chapter 3 (pp. 21-37) of part one
- Select a process area of your choice
  - Read the description of this PA in part two of the document
  - Also read about the elaboration of the generic goals and practices for this PA (you have to pick the info for the respective PA from pp. 65-120)

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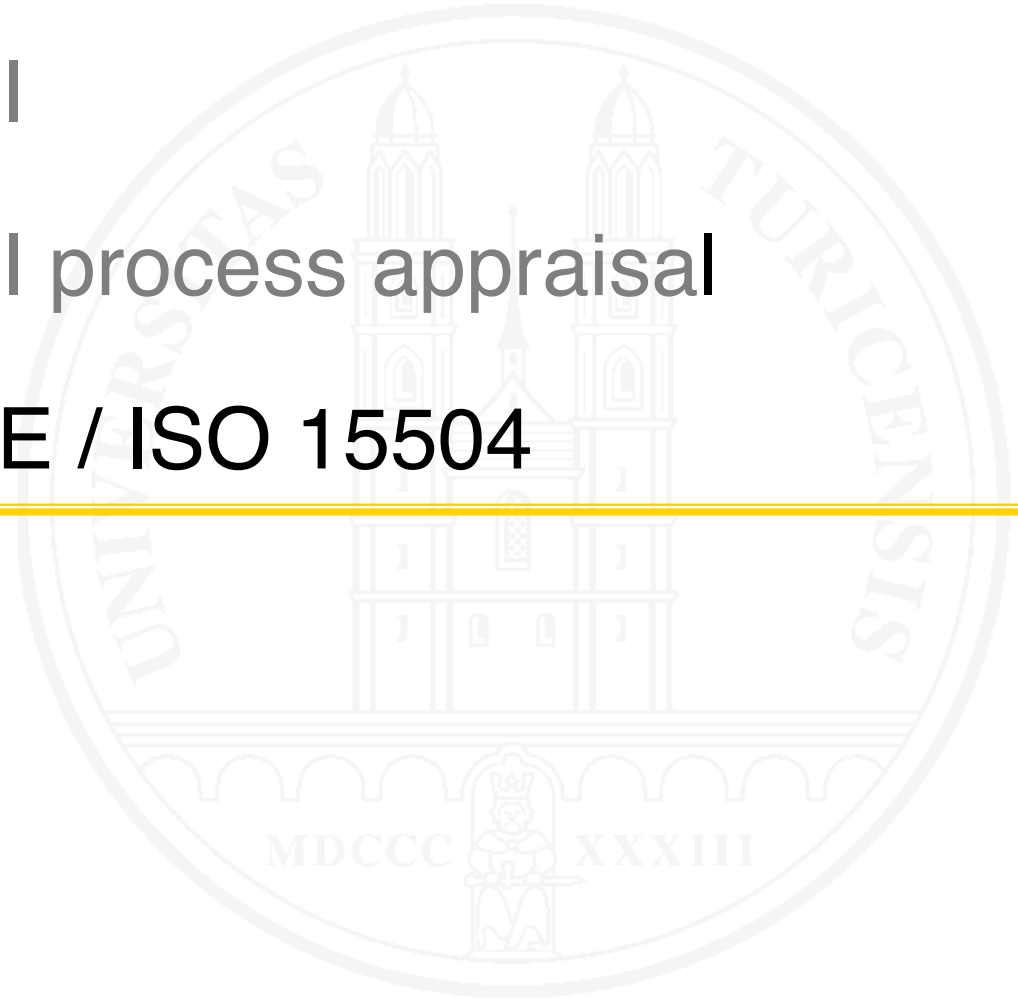

SPICE / ISO/IEC 15504

- History:
  - Bootstrap was an EU Esprit project for developing a process assessment method which ran from 1990-92
  - 1993 a consortium was found to develop the results into an international standard
  - This endeavor was called SPICE (Software Process Improvement and Capability Evaluation; later Software Process Improvement and Capability dEtermination)
  - In 1997, the draft standard SPICE / ISO 15504 was published as a ISO technical report
  - In 2004, it became an approved ISO/IEC standard
- Currently the only standardized alternative to CMMI

Overview

- Construction of a capability profile
  - of the processes of an organization
  - based on the assessment of nine process attributes
- Capability measured on a six-level ordinal scale

Capability levels

5 Optimizing process

4 Predictable process

3 Established process

2 Managed process

1 Performed process

0 Incomplete process

Process attributes

1.1 Process Performance

2.1 Performance Management

2.2 Work Product Management

3.1 Process Definition

3.2 Process Deployment

4.1 Process Measurement

4.2 Process Control

5.1 Process Innovation

5.2 Process Optimization

Assessment of process attributes

Collected data on a process are assessed on a four-point scale:

- Not achieved (0 - 15%)
- Partially achieved (>15% - 50%)
- Largely achieved (>50% - 85%)
- Fully achieved (>85% - 100%).

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CMMI: http://cmmiinstitute.com

SPICE: http://ibpi.org/standard/isoiec-15504/