INF5180: Software Product- and Process Improvement in Systems Development

Part 09:

Process Assessment

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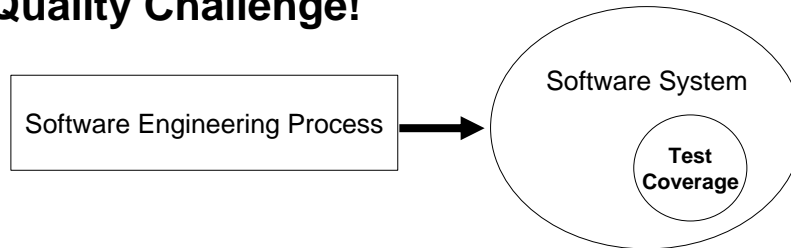Dr. Dietmar Pfahl

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Spring 2010

Contents

- CMM(I) History and Overview
- Structure
  - Specific and generic goals
  - Specific and generic practices
- Process Areas
- Evaluation
- Continuous Process Improvement
- Dissemination and Results

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The Quality Challenge!

Software System

Software Engineering Process →

Test Coverage

> **"The quality of a system is highly influenced by the quality of the process used to acquire, develop, and maintain it." (W.Humphrey)**

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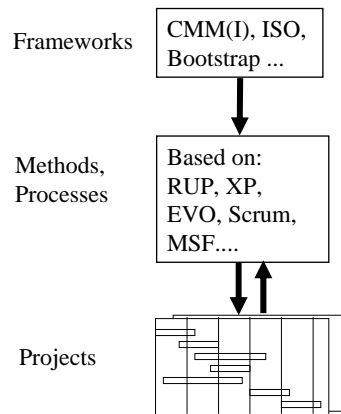---

The Software Business ...

- Problems with estimation
  - Budget overruns
  - Time overruns

- Problems with quality
  - Struggle with defect correction instead of avoidance
  - Struggle with unsatisfied customers

- No well-defined process
  - Starting "from scratch" in every project
  - Good practices are sacrificed under stress

- Critical aspects
  - Relying on "heroes"
  - Overtime
  - Fire-fighting

... and this is even more the case for system development

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How to Sustain Good Practice?

Frameworks

| CMM(I), ISO, Bootstrap ... |

Methods, Processes

| Based on: RUP, XP, EVO, Scrum, MSF.... |

Projects

Maturity/quality frameworks support
- evaluating improvement needs and achievements
- organizational change
- cultural change
- knowledge creation
- measurement

Much good practice is prescribed in explicit process models. But you should **choose right** and **adapt** to your needs

It is important to identify and learn about good practices from within the projects. Update the process model after each project!

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Origins of CMM*

- DoD** decided in the 80s to do something about everything that went wrong in its expensive software projects (often involving suppliers).
    - Ada didn't solve the problems (as many had thought/hoped)
    - Appraisals showed that there was a management problem

- Watts Humphrey left IBM for SEI and began developing CMM in 1986

- *Managing the Software Process* by W. Humphrey published in 1989

- Version 1.1 published in 1993 – is still the most used model

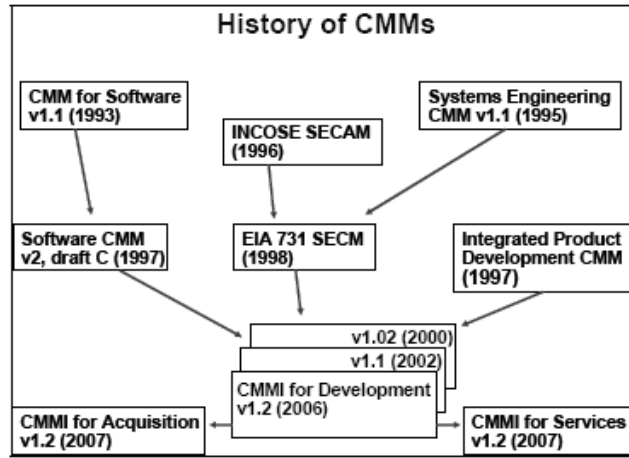- CMMI first published in 1999, version 1.2 published in 2006.

CMM = Capability Maturity Model
DoD** = Department of Defense

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History

Source: CMMI® for
Development, Version 1.2
(CMMI-DEV, V1.2),
CMU/SEI-2006-TR-008,
ESC-TR-2006-008, August
2006

http://www.sei.cmu.edu/cmmi/

History of CMMs

CMM for Software v1.1 (1993)

INCOSE SECAM (1996)

Systems Engineering CMM v1.1 (1995)

Software CMM v2, draft C (1997)

EIA 731 SECM (1998)

Integrated Product Development CMM (1997)

v1.02 (2000)
v1.1 (2002)

CMMI for Development v1.2 (2006)

CMMI for Acquisition v1.2 (2007)

CMMI for Services v1.2 (2007)

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CMMI Family

- 4 different models (with very small differences)
  - **CMMI-SE/SW/IPPD/SS**
  - **CMMI-SE/SW/IPPD**
  - **CMMI-SE/SW**
  - **CMMI-SW**
  - All models have a continuous and staged representation.

- Definitions:
  - SS: Supplier Sourcing
  - IPPD: Integrated Product and Process Development
  - SE: Systems Engineering
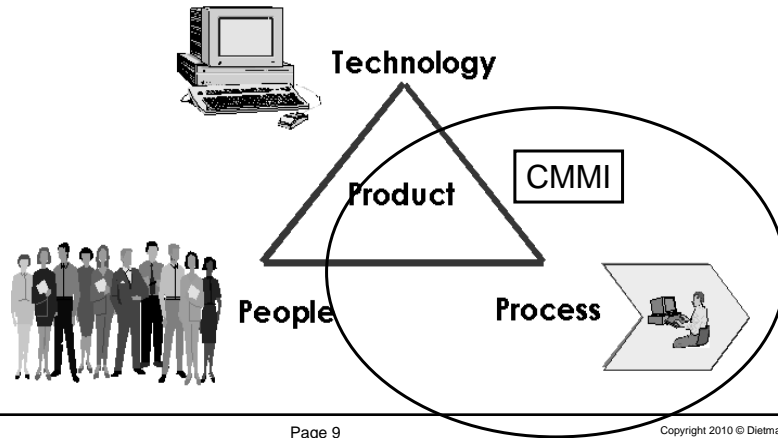 - SW: Software Engineering

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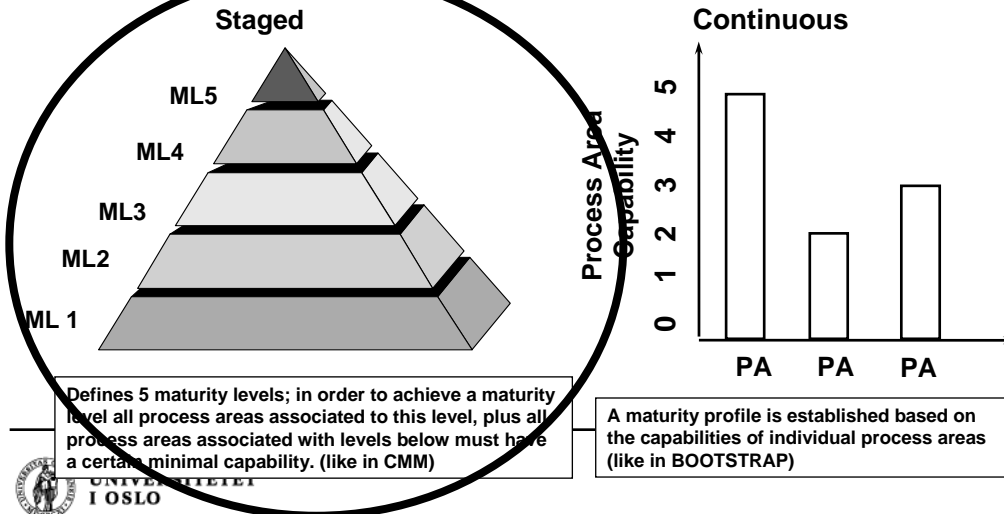
CMMI Scope

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Staged versus Continuous Representation

Staged

Continuous

ML5

ML4

ML3

ML2

ML 1

Process Area Capability

5 4 3 2 1 0

PA PA PA

Defines 5 maturity levels; in order to achieve a maturity level all process areas associated to this level, plus all process areas associated with levels below must have a certain minimal capability. (like in CMM)

A maturity profile is established based on the capabilities of individual process areas (like in BOOTSTRAP)

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Levels and Process Areas (staged)

Level	Process Areas
5 Optimizing	**Causal Analysis and Resolution** **Organizational Innovation and Deployment**
4 Quantitatively Managed	**Quantitative Project Management** **Organizational Process Performance**
3 Defined	**Requirements Development** **Technical Solution** **Product Integration** **Verification** **Validation** **Organizational Process Focus** **Organizational Process Definition** **Organizational Training** **Risk Management** **Integrated Project Management (for IPPD*)** **Integrated Teaming*** **Integrated Supplier Management**** **Decision Analysis and Resolution** **Organizational Environment for Integration***
2 Managed	**Requirements Management** **Project Planning** **Project Monitoring and Control** **Supplier Agreement Management** **Measurement and Analysis** **Process and Product Quality Assurance** **Configuration Management**
1 Performed	

*** Integrated Product/Process Development (IPPD) –
add-on to the Engineering processes
** Acquisition – add-on to the Engineering processes**

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CMMI Level 2 – *Managed* means …

- Adhering to organizational policies
- Following established plans and process descriptions
- Providing adequate resources (including funding, people, and tools)
- Assigning responsibility and authority for performing the process
- Training the people performing and supporting the process
- Placing designated work products under appropriate levels of configuration management
- Identifying and involving relevant stakeholders
- Monitoring and controlling the performance of the process against the plans for performing the process and taking corrective actions
- Objectively evaluating the process, its work products, and its services for adherence to the process descriptions, standards, and procedures, and addressing noncompliance
- Reviewing the activities, status, and results of the process with higher level management, and taking corrective action
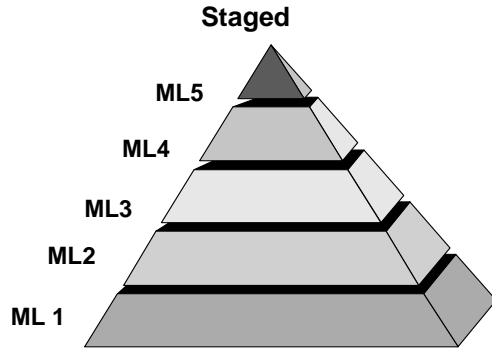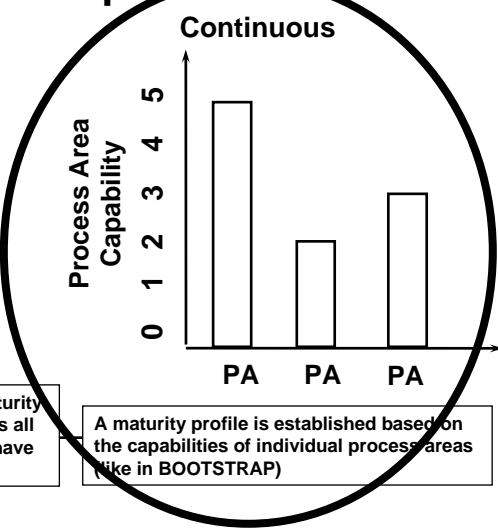
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Staged versus Continuous Representation

Staged

ML5
ML4
ML3
ML2
ML 1

Defines 5 maturity levels; in order to achieve a maturity level all process areas associated to this level, plus all process areas associated with levels below must have a certain minimal capability. (like in CMM)

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Continuous

Process Area Capability

5 4 3 2 1 0

PA   PA   PA

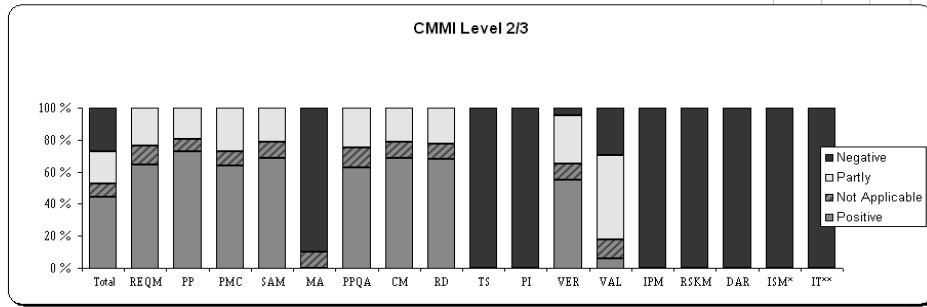**A maturity profile is established based on the capabilities of individual process areas (like in BOOTSTRAP)**

Assessment Results (continuous)

Total CMMI Complience:	63 %	**Tailoring: Use of Not Applicable:**	8 %
CMMI Level 2 complience:	77 %	CMMI Level 3 complience:	22 %

CMMI Level 2/3

100 %
80 %
60 %
40 %
20 %
0 %

Total REQM PP PMC SAM MA PPQA CM RD TS PI VER VAL IPM RSKM DAR ISM* IT**

■ Negative
□ Partly
■ Not Applicable
■ Positive

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Research Results at Simula

Headline:
That's why it goes so wrong

On average:
35% cost overrun
25% time overrun

50% of all projects are really bad

Reasons:
Underestimation of complexity
and thus
of the risks associated with
sw/system development

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COMPUTERWORLD

Nr. 44 · Uke 42
Fredag
17. oktober
2003
21. årgang
Løssalg kr. 40

WWW · COMPUTERWORLD · NO

20 år

Derfor går det så galt

Endelig er det vitenskapelig bevist: It-prosjekter blir i snitt 35 prosent dyrere og tar 25 prosent lenger tid enn planlagt. Prosjektene er nesten alltid langt mer komplekse enn antatt, hevder forskere ved Simula-senteret. – Halvparten av alle prosjekter går riktig galt. Som regel på grunn av en sterk undervurdering av risiko, sier professor Magne Jørgensen.
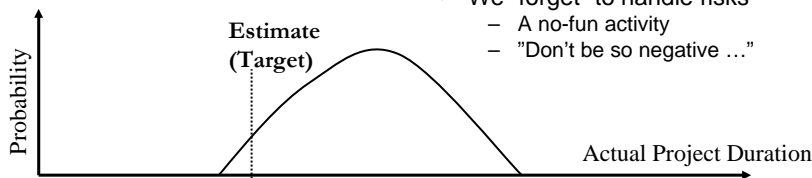
SIDE 10 OG 11

VANN OVER HODET: It-prosjekter blir alltid mer omfattende enn man tror i utgangspunktet, fastslår Kjetil Moløkken og Magne Jørgensen ved Simula-senteret.

It is human to make mistakes …

Source:
Magne Jørgensen et.al. (2003)
"Better sure than safe?
Overconfidence in judgment based software development effort prediction intervals"

- Overestimating your own skills
  - "Everyone" is an above average driver...*
  - Study at Simula shows similar tendency for developers

- We estimate "internally"
  - Fail to look at the project from outside
    - Which experience was made with similar projects?
    - Have there been done at all similar projects before?

- We "forget" to handle risks
  - A no-fun activity
  - "Don't be so negative …"
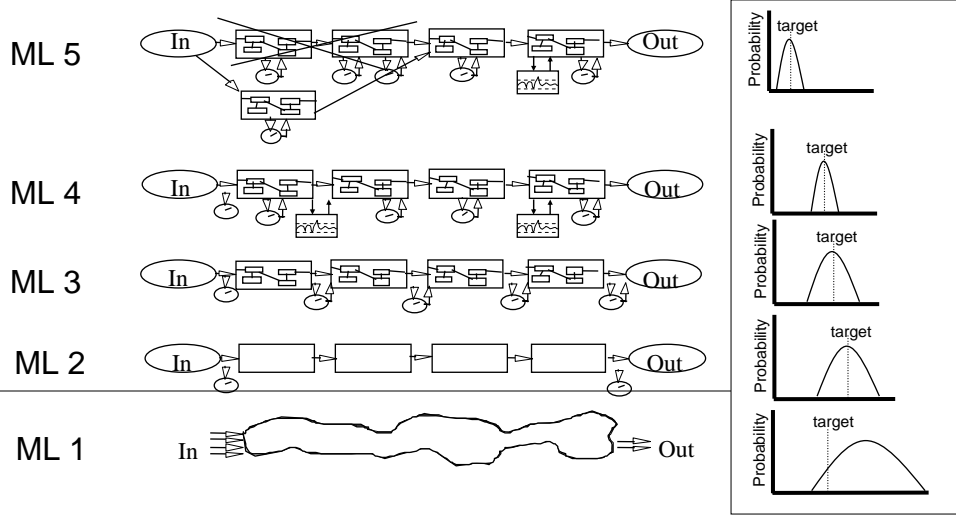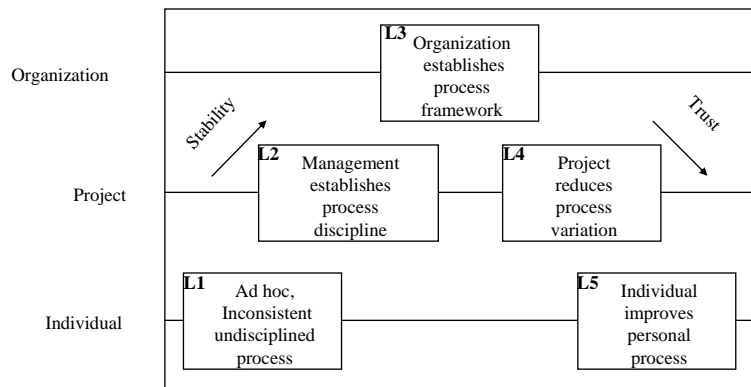
*) Applies mostly to men

Estimate
(Target)

Probability

Actual Project Duration

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CMMI – How much we now about our projects?

ML 5

ML 4

ML 3

ML 2

ML 1

Organizational Changes

Organization

L3 Organization establishes process framework

Stability

Trust

Project

L2 Management establishes process discipline

L4 Project reduces process variation

Individual

L1 Ad hoc, Inconsistent undisciplined process

L5 Individual improves personal process

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CMMI ®

STRUCTURE

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Staged or Continuous Representation?

Staged

ML5
ML4
ML3
ML2
ML 1

Defines 5 maturity levels; in order to achieve a maturity level all process areas associated to this level, plus all process areas associated with levels below must have a certain minimal capability. (like in CMM)

Continuous

Process Area Capability

5
4
3
2
1
0

PA   PA   PA

A maturity profile is established based on the capabilities of individual process areas (like in BOOTSTRAP)

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Levels and Process Areas (staged)

Level	Process Areas
5 Optimizing	Causal Analysis and Resolution Organizational Innovation and Deployment
4 Quantitatively Managed	Quantitative Project Management Organizational Process Performance
3 Defined	Requirements Development Technical Solution Product Integration Verification Validation Organizational Process Focus Organizational Process Definition Organizational Training Risk Management Integrated Project Management (for IPPD*) Integrated Teaming* Integrated Supplier Management** Decision Analysis and Resolution Organizational Environment for Integration*
2 Managed	Requirements Management Project Planning Project Monitoring and Control Supplier Agreement Management Measurement and Analysis Process and Product Quality Assurance Configuration Management
1 Performed	

* Integrated Product/Process Development (IPPD) – add-on to the Engineering processes
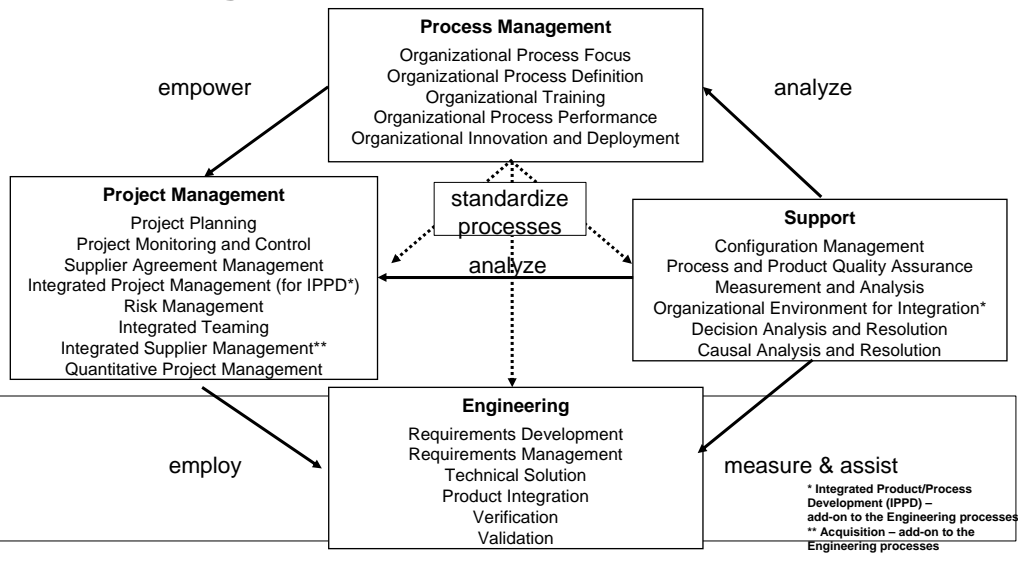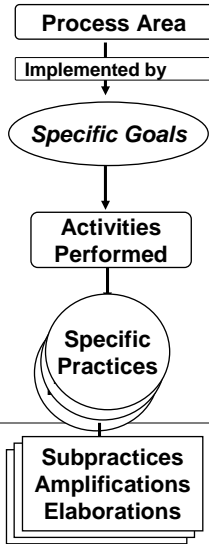** Acquisition – add-on to the Engineering processes

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Page 21

Structuring the Process Areas (continuous)

Process Management

Organizational Process Focus
Organizational Process Definition
Organizational Training
Organizational Process Performance
Organizational Innovation and Deployment

empower

analyze

standardize
processes

analyze

Project Management

Project Planning
Project Monitoring and Control
Supplier Agreement Management
Integrated Project Management (for IPPD*)
Risk Management
Integrated Teaming
Integrated Supplier Management**
Quantitative Project Management

Support

Configuration Management
Process and Product Quality Assurance
Measurement and Analysis
Organizational Environment for Integration*
Decision Analysis and Resolution
Causal Analysis and Resolution

Engineering

Requirements Development
Requirements Management
Technical Solution
Product Integration
Verification
Validation

employ

measure & assist

* Integrated Product/Process Development (IPPD) – add-on to the Engineering processes
** Acquisition – add-on to the Engineering processes

Example: Requirement Management

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.
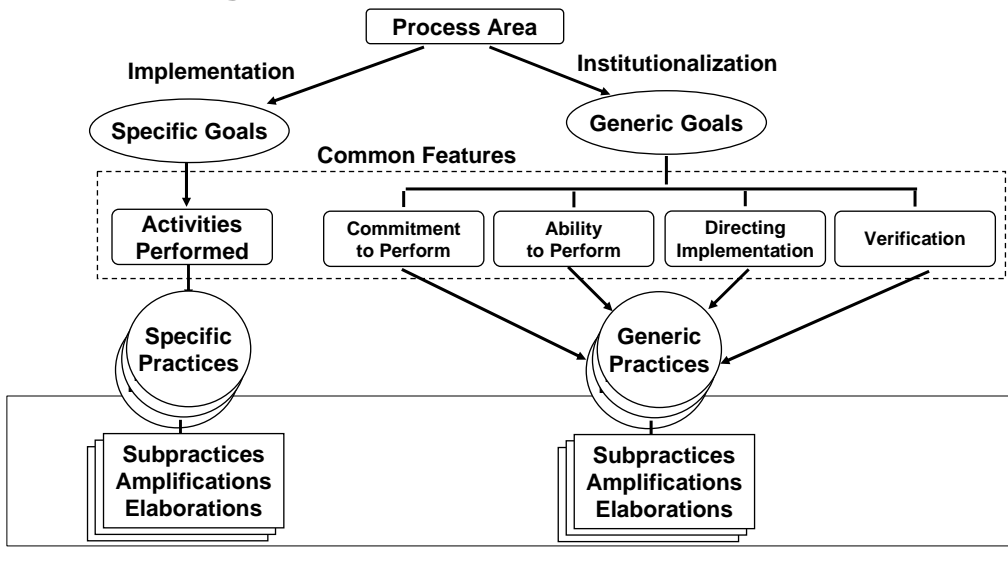
Process Area

Implemented by

Specific Goals

SG1: *Requirements are managed and inconsistencies with project plans and work products are identified.*

Activities Performed

Specific Practices

SP 1.1   Obtain an Understanding of Requirements

. . . .

Subpractices Amplifications Elaborations

1.   Establish criteria for distinguishing appropriate requirements providers.
2.   Establish objective criteria for the acceptance of requirements.

Structuring the Process Areas

Process Area

Implementation   **Institutionalization**

Specific Goals   **Generic Goals**

Common Features

Activities Performed   **Commitment to Perform**   **Ability to Perform**   **Directing Implementation**   **Verification**

Specific Practices   **Generic Practices**

Subpractices Amplifications Elaborations   **Subpractices Amplifications Elaborations**

Specific versus Generic

- Addresses one process area
- Describes activities used to **implement** the process area

- Addresses all process areas
- Describes activities that **institutionalize** the process area

Example: Requirements Mgmt.

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

GG 1 Achieve Specific Goals
    GP 1.1 Perform Base Practices
GG 2 Institutionalize a Managed Process
    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 Manage Configurations
    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
GG 3 Institutionalize a Defined Process
    GP 3.1 Establish a Defined Process
    GP 3.2 Collect Improvement Information
...

Page 25

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Basis for Institutionalization

Commitment to perform

Will we do it?

GP 2.1 Establish an Organizational Policy

Ability to perform

Can we do it?

GP 2.2 Plan the Process
GP 2.3 Provide Resources
GP 2.4 Assign Responsibility
GP 2.5 Train People

SP's
What we do

GP 2.6 Manage Configurations
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

Are we doing it?

Directing Implementation

How well are we doing it?

Verification

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Example: GP 2.2 – Plan the Process

Establish and maintain the plan for performing the process.

The purpose of this generic practice is to determine what is needed to perform the process and achieve the established objectives, to prepare a plan for performing the process, to prepare a process description, and to get agreement on the plan from relevant stakeholders. [GP104]

Requirements for the process's specified work products and for performing the work may be derived from other requirements. In the case of a project's processes, they may come from that project's requirements management process; in the case of an organization's process, they may come from organizational sources. [GP104.N101]

The objectives for the process may be derived from other plans (e.g., the project plans). Included are objectives for the specific situation, including quality, cost, and schedule objectives. For example, an objective might be to reduce the cost of performing a process for this implementation...

Although a gen... the practical im... process area. O... as they relate t... this generic pra... process area m... with the Project... practice impose...

Stakeholder

A "stakeholder" is a group or individual that is affected by or in some way accountable for the outcome of an undertaking. Stakeholders may include project members, suppliers, customers, end users, and others. [FM114.HDA102.HDB104.T101]

planning described by this generic practice as applied to the Project Planning process area typically would not be addressed by the processes associated with other process areas in the model. Therefore, the generic practice sets an expectation that the project planning process itself be planned. It is important to be aware of the extent to which this generic practice may either reinforce expectations set elsewhere in the model, or set new expectations that should be addressed. [GP104.N102]

Establishing a plan includes documenting the plan and providing a process description. Maintaining the plan includes changing it as necessary, in response to either corrective actions or to changes in requirements and objectives for the process. [GP104.N103]

The [GP104

Subpractices

1. Obtain management sponsorship for performing the process. [GP104.SubP101]

2. Define and document the process description. [GP104.SubP102]

    The process description, which includes relevant standards and procedures, may be included as part of the plan for performing the process or may be included in the plan by reference. [GP104.SubP102.N101]

3. Define and document the plan for performing the process.

    ...e document, embedded in a more comprehensive ...s multiple documents. In the case of the plan being ...uments, ensure that a coherent picture is preserved ...may be hardcopy or softcopy. [GP104.SubP103.N102]

4. Review the plan with relevant stakeholders and get their agreement. [GP104.SubP104]

    This includes reviewing that the planned process satisfies the applicable policies, plans, requirements, and standards to provide assurance to relevant stakeholders. [GP104.SubP104.N101]

5. Revise the plan as necessary. [GP104.SubP105]

All Generic Goals

GG 1	**Achieve Specific Goals** [CL102.GL101]
	The process supports and enables achievement of the specific goals of the process area by transforming identifiable input work products to produce identifiable output work products.
GG 2	**Institutionalize a Managed Process** [CL103.GL101]
	The process is institutionalized as a managed process.
GG 3	**Institutionalize a Defined Process** [CL104.GL101]
	The process is institutionalized as a defined process.
GG 4	**Institutionalize a Quantitatively Managed Process** [CL105.GL101]
	The process is institutionalized as a quantitatively managed process.
GG 5	**Institutionalize an Optimizing Process** [CL106.GL101]
	The process is institutionalized as an optimizing process.

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CMMI

PROCESS AREAS

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CMMI Level 2 – *Managed* means …

- Adhering to organizational policies
- Following established plans and process descriptions
- Providing adequate resources (including funding, people, and tools)
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- Training the people performing and supporting the process
- Placing designated work products under appropriate levels of configuration management
- Identifying and involving relevant stakeholders
- Monitoring and controlling the performance of the process against the plans for performing the process and taking corrective actions
- Objectively evaluating the process, its work products, and its services for adherence to the process descriptions, standards, and procedures, and addressing noncompliance
- Reviewing the activities, status, and results of the process with higher level management, and taking corrective action

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CMMI Level 2

Process Areas

- Requirements Management
- Project Planning
- Project Monitoring and Control
- Supplier Agreement Management
- Measurement and Analysis
- Process and Product Quality Assurance
- Configuration Management

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Requirements Management – REQM

Purpose

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.

SG 1   Manage Requirements
Requirements are managed and inconsistencies with project plans and work products are identified.

GG 2   Institutionalize a Managed Process
The process is institutionalized as a managed process.

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Requirements Management – REQM

Practices by Goal:

SG 1   Manage Requirements

Requirements are managed and inconsistencies with project plans and work products are identified. [PA146.IG101]

SP 1.1-1   Obtain an Understanding of Requirements

Develop an understanding with the requirements providers on the meaning of the requirements. [PA146.IG101.SP101]

SP 1.2-2   Obtain Commitment to Requirements

Obtain commitment to the requirements from the project participants. [PA146.IG101.SP102]

SP 1.3-1   Manage Requirements Changes

Manage changes to the requirements as they evolve during the project. [PA146.IG101.SP103]

SP 1.4-2   Maintain Bidirectional Traceability of Requirements

Maintain bidirectional traceability among the requirements and the project plans and work products. [PA146.IG101.SP104]

SP 1.5-1   Identify Inconsistencies between Project Work and Requirements

Identify inconsistencies between the project plans and work products and the requirements. [PA146.IG101.SP105]

GG 1   Achieve Specific Goals

The process supports and enables achievement of the specific goals of the process area by transforming identifiable input work products to produce identifiable output work products.

GP 2.5   Train People

Train the people performing or supporting the process as needed. [GP107]

GP 2.6   Manage Configurations

Place designated work products of the process under appropriate levels of configuration management. [GP109]

GP 2.7   Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders as planned. [GP124]

GP 2.8   Monitor and Control the Process

Monitor and control the process against the plan for performing the process and take appropriate corrective action. [GP110]

GP 2.9   Objectively Evaluate Adherence

Objectively evaluate adherence of the process against its process description, standards, and procedures, and address noncompliance. [GP113]

GP 2.10   Review Status with Higher Level Management

Review the activities, status, and results of the process with higher level management and resolve issues. [GP112]

Project Planning – PP

Purpose

The purpose of Project Planning is to establish and maintain plans that define project activities.

SG 1   Establish Estimates
Estimates of project planning parameters are established and maintained.

SG 2   Develop a Project Plan
A project plan is established and maintained as the basis for managing the project.

SG 3   Obtain Commitment to the Plan
Commitments to the project plan are established and maintained.

GG1 & 2

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Project Monitoring and Control – PMC

Purpose

The purpose of Project Monitoring and Control is to provide understanding into the project's progress so that appropriate corrective actions can be taken when the project's performance deviates significantly from the plan.

> **SG 1   Monitor Project Against Plan**
> *Actual performance and progress of the project is monitored against the project plan.*
>
> **SG 2   Manage Corrective Action to Closure**
> *Corrective actions are managed to closure when the project's performance or results deviate significantly from the plan.*

GG1 & 2

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Supplier Agreement Management – SAM

Purpose

The purpose of Supplier Agreement Management is to manage the acquisition of products and services from suppliers external to the project for which there exists a formal agreement.

> **SG 1   Establish Supplier Agreements**
> *Agreements with the suppliers are established and maintained.*
>
> **SG 2   Satisfy Supplier Agreements**
> *Agreements with the suppliers are satisfied by both the project and the supplier.*

GG1 & 2

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Measurement and Analysis – MA

Purpose

The purpose of Measurement and Analysis is to develop and sustain a measurement capability that is used to support management information needs.

SG 1   Align Measurement and Analysis Activities
Measurement objectives and practices are aligned with identified information needs and objectives.

SG 2   Provide Measurement Results
Measurement results that address identified information needs and objectives are provided.

GG1 & 2

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Process and Product Quality Assurance – PPQA

Purpose

The purpose of Process and Product Quality Assurance is to provide staff and management with objective insight into the processes and associated work products.

SG 1   Objectively Evaluate Processes and Work Products
Adherence of the performed process and associated work products and services to applicable process descriptions, standards and procedures is objectively evaluated.

SG 2   Provide Objective Insight
Noncompliance issues are objectively tracked and communicated, and resolution is ensured.

GG1 & 2

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Configuration Management – CM

Purpose

The purpose of Configuration Management is to establish and maintain the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits.

SG 1   Establish Baselines
Baselines of identified work products are established and maintained.

SG 2   Track and Control Changes
Changes to the work products under configuration management are tracked and controlled.

SG 3   Establish Integrity
Integrity of baselines is established and maintained.

GG1 & 2

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CMMI Level 3 – *Defined* means …

- Establish a **standard development process** which is
    - **Well-defined** at the organizational level
    - **in use** on a broad scale
    - the basis for all learning and storing of experience (*best practices*)
    - the starting point for special adjustments (*tailoring*)

- The organization stresses the use of the process:
    - creates process groups ("SEPG")
    - provides experience mechanism ("de-briefing", project evaluation etc)
    - links experience data to the process
    - offers training about the process
    - and ties technical training into the process
    - clearly defines interfaces between groups

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CMMI Level 3

Process Areas

- Requirements Development
- Technical Solution
- Product Integration
- Verification
- Validation

- Organizational Process Focus
- Organizational Process Definition
- Organizational Training
- Integrated Project Management
- Risk Management
- Decision Analysis and Resolution

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Requirements Development – RD

Purpose

The purpose of Requirements Development is to produce and analyze customer, product, and product component requirements.

SG 1   Develop Customer Requirements
Stakeholder needs, expectations, constraints, and interfaces are collected and translated into customer requirements.

SG 2   Develop Product Requirements
Customer requirements are refined and elaborated to develop product and product component requirements for the product life cycle.

SG 3   Analyze and Validate Requirements
The requirements are analyzed and validated, and a definition of required functionality is developed.

GG1-3

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Technical Solution – TS

Purpose

The purpose of Technical Solution is to develop, design, and implement solutions to requirements. Solutions, designs and implementations encompass products, product components, and product related processes either singly or in combinations as appropriate.

SG 1   Select Product Component Solutions
Product or product component solutions, including applicable product related processes, are selected from alternative solutions.

SG 2   Develop the Design
Product or product component designs are developed.

SG 3   Implement the Product Design
Product components, and associated support documentation, are implemented from their designs.

GG1-3

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Product Integration – PI

Purpose

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.

SG 1   Prepare for Product Integration
The strategy for conducting product integration is established and maintained.

SG 2   Ensure Interface Compatibility
The product component interfaces, both internal and external, are compatible.

SG 3   Assemble Product Components and Deliver the Product
Verified product components are assembled and the integrated, verified, and validated product is delivered.

GG1-3

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Verification – VER

Purpose

The purpose of Verification is to assure that selected work products meet their specified requirements.

SG 1   Prepare for Verification
Preparation for verification is conducted.

SG 2   Perform Peer Reviews
Peer reviews are performed on selected work products.

SG 3   Verify Selected Work Products
Selected work products are verified against their specified requirements.

GG1-3

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Validation – VAL

Purpose

The purpose of Validation is to demonstrate that a product or product component fulfills its intended use when placed in its intended environment.

SG 1   Prepare for Validation
Preparation for validation is conducted.

SG 2   Validate Product or Product Components
The product or product components are validated to ensure that they are suitable for use in their intended operating environment.

GG1-3

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Organizational Process Focus – OPF

Purpose

The purpose of Organizational Process Focus is to establish and maintain an understanding of the organization's processes and process assets, and to identify, plan, and implement the organization's process improvement activities.

SG 1   Determine Process Improvement Opportunities
Strengths, weaknesses, and improvement opportunities for the organization's processes are identified periodically and as needed.

SG 2   Plan and Implement Process Improvement Activities
Improvements are planned and implemented, process assets are deployed, and process-related experiences are incorporated into the organization's process assets.

GG1-3

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Organizational Process Definition – OPD

Purpose

The purpose of Organizational Process Definition is to establish and maintain a usable set of organizational process assets.

SG 1   Create Organizational Process Assets
A set of organizational process assets is available.

SG 2   Make Supporting Process Assets Available
Process assets that support the use of the organization's set of standard processes are available.

GG1-3

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Organizational Training – OT

Purpose

The purpose of Organizational Training is to develop the skills and knowledge of people so they can perform their roles effectively and efficiently.

SG 1   Identify Training Needs and Make Training Available
Training to support the organization's management and technical roles is identified and made available.

SG 2   Provide Necessary Training
Training necessary for individuals to perform their roles effectively is provided.

GG1-3

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Integrated Project Management – IPM

Purpose

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
The project is conducted using a defined process that is tailored from the organization's of standard processes.

SG 2   Coordinate and Collaborate with Relevant Stakeholders
The project coordinates and collaborates with the relevant stakeholders.

GG1-3

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Risk Management – RM

Purpose

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 cycle to mitigate adverse impacts on achieving objectives.

SG 1 Prepare for Risk Management
Preparation for risk management is conducted.

SG 2 Identify and Analyze Risks
Risks are identified and analyzed to determine their relative importance.

SG 3 Mitigate Risks
Risks are handled and mitigated, where appropriate, to reduce adverse impacts on achieving objectives.

GG1-3

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Decision Analysis and Resolution – DAR

Purpose

The purpose of Decision Analysis and Resolution is to make decisions using a structured approach that evaluates identified alternatives against established criteria.

SG 1   Evaluate Alternatives
Decisions are based on an evaluation of alternatives using established criteria.

GG1-3

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Learning and Improvement in SW Organisations

Pre-defined process models RUP, XP, Scrum, Cleanroom...

Process models exist on 3 levels: family/standard level, organizational level, and project level

Experience transfer between projects (1), project-specific processes (2) and via organizational processes (3)

Inspires

Generic Process model

3

Project type 1 process model

2

Project type 2 process model

Project type n process model

1

CMMI ®

EVALUATION

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CMMI Evaluation – How to do it?

Many models, forms and formalisms exist:

- Official *appraisal*: SCAMPI[SM] (replaced CBA IPI* and SCE**)
- Company-specific assessments (e.g., Siemens Assessment)
- Light assessments
- Ultra-light assessments
- Self-assessment
- Interim-evaluation / Mini-assessment
- Based on open interviews
- Based on structured interviews
- Based on questionnaires   * CMM-Based Appraisal for Internal Process Improvement
                               ** Software Capability Evaluation

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http://www.kt-bits.com/appraisals.htm

CMMI Evaluation – Questionnaire Example

- **Related to Requirements Development**

- Note: This example refers to the SPICE model (cf. lecture Part 10), process ENG.2.2 - Analyze Software Requirements

- Similar questionnaires exist for CMMI (and other process assessment approaches)

- These questionnaires are NOT standardised

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SCAMPI[SM]

- **Standard CMMI Appraisal Method for Process Improvement**
  - Is a group of evaluation methods, both suitable to monitor progress on the way and for reliable benchmarking of organizations
  - Complies with ISO 15504

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The SCAMPI[SM] Family

Name:	Class A[1]	Class B[2]	Class C[3]
Type:	Benchmark	Mini-appraisal	Pulse Taking
Objectiveness:	High	Medium	Low
Evidence required:	Document Review Interviews Instrument	Document Review Interviews Instrument *(pick two)*	Document Review Interviews Instrument *(pick one)*
Rating:	Formal Rating	Not formal	Not formal
Responsible:	Lead Appraiser	Lead Appraiser *(preferred)*	Trained Leader
Team:	Appraisal Team *(large)*	Appraisal Team *(medium)*	Appraisal Team *(small)*

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1: Replaces CMM Based Appraisal for Internal Process Improvement (CBA IPI)
2: Replaces Mini-Assessment
3: Replaces Project Quick Look Assessment (PQLA)

Appraisal Team Members (ATM) – Requirements

- Appraisal Team must
  - have a total of 25 years of field experience with an average of 6 years
  - have a total of 10 years of management experience and at least one ATM with at least 6 years experience as a manager
  - have experience in the life cycles in use by the organizational unit
    - At least two ATMs should have experience as practitioners

- ATMs should
  - not be managers of any of the selected projects
  - not be in the direct supervisory chain of any of the interviewees
  - have good written and oral communication skills
  - have the ability to facilitate the free flow of communication
  - have the ability to perform as team players and negotiate consensus
  - have participated (at least 50%) in a previous process appraisal
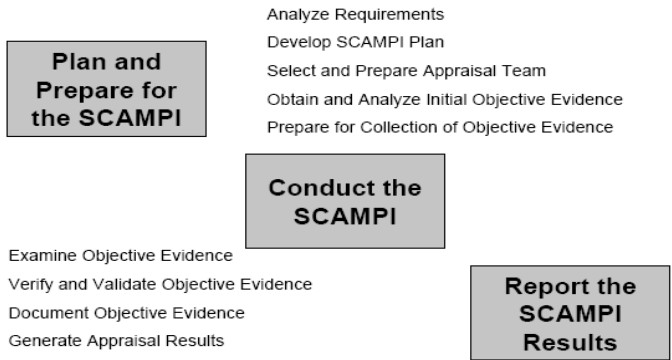 - be perceived by the appraisal sponsor as credible

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Practice Implementation Indicator Descriptions

PIID Type	Description	Examples
Direct	Tangible output resulting directly from implementation of a practice	Typical work products
Indirect	Artifacts that are a side-effect or indicative of performing a practice	Typical work products, meeting minutes, reviews, logs, reports
Affirmation	Oral or written statements confirming or supporting implementation of the practice	Interviews, questionnaires, briefings, demonstrations

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The SCAMPI Process

Plan and Prepare for the SCAMPI

Analyze Requirements
Develop SCAMPI Plan
Select and Prepare Appraisal Team
Obtain and Analyze Initial Objective Evidence
Prepare for Collection of Objective Evidence

Conduct the SCAMPI

Examine Objective Evidence
Verify and Validate Objective Evidence
Document Objective Evidence
Generate Appraisal Results

Report the SCAMPI Results

TeraQuest

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The SCAMPI Process (cont'd)

Phase	Process	Purpose	Activities
1 Plan and Prepare for Appraisal	1.1 Analyze Requirements	Understand the business needs of the organizational unit for which the appraisal is being requested. The appraisal team leader will collect information and help the appraisal sponsor match appraisal objectives with their business objectives.	1.1.1 Determine Appraisal Objectives 1.1.2 Determine Appraisal Constraints 1.1.3 Determine Appraisal Scope 1.1.4 Determine Outputs 1.1.5 Obtain Commitment to Appraisal Input
	1.2 Develop Appraisal Plan	Document requirements, agreements, estimates, risks, method tailoring, and practice considerations (e.g., schedules, logistics, and contextual information about the organization) associated with the appraisal. Obtain, record, and make visible the sponsor's approval of the appraisal plan.	1.2.1 Tailor Method 1.2.2 Identify Needed Resources 1.2.3 Determine Cost and Schedule 1.2.4 Plan and Manage Logistics 1.2.5 Document and Manage Risks 1.2.6 Obtain Commitment to Appraisal Plan
	1.3 Select and Prepare Team	Ensure that an experienced, trained, appropriately qualified team is available and prepared to execute the appraisal process.	1.3.1 Identify Team Leader 1.3.2 Select Team Members 1.3.3 Prepare Team
	1.4 Obtain and Analyze Initial Objective Evidence	Obtain information that facilitates site-specific preparation. Obtain data on model practices used. Identify potential issue areas, gaps, or risks to aid in refining the plan. Get preliminary understanding of the organizational unit's operations and processes.	1.4.1 Prepare Participants 1.4.2 Administer Instruments 1.4.3 Obtain Initial Objective Evidence 1.4.4 Inventory Objective Evidence
	1.5 Prepare for Collection of Objective Evidence	Plan and document specific data collection strategies including sources of data, tools and technologies to be used, and contingencies to manage risk of insufficient data.	1.5.1 Perform Readiness Review 1.5.2 Prepare Data Collection Plan 1.5.3 Replan Data Collection (if needed)

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The SCAMPI Process (cont'd)

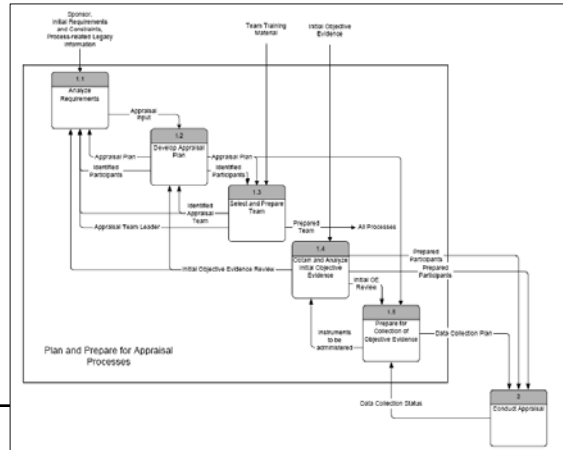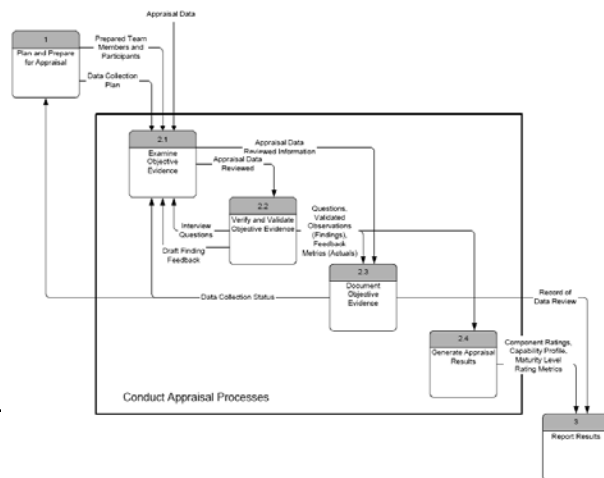| Phase	Process	Purpose	Activities
2 Conduct Appraisal	2.1 Examine Objective Evidence	Collect information about the practices implemented in the organizational unit and relate the resultant data to the reference model. Perform the activity in accordance with the data collection plan. Take corrective actions and revise the data collection plan as needed.	2.1.1 Examine Objective Evidence from Instruments 2.1.2 Examine Objective Evidence from Presentations 2.1.3 Examine Objective Evidence from Documents 2.1.4 Examine Objective Evidence from Interviews
	2.2 Verify and Validate Objective Evidence	Verify the implementation of the organizational unit's practices for each instantiation. Validate the preliminary findings, describing gaps in the implementation of model practices. Each implementation of each practice is verified so it may be compared to CMMI practices, and the team characterizes the extent to which the practices in the model are implemented. Gaps in practice implementation are captured and validated with members of the organizational unit. Exemplary implementations of model practices may be highlighted as strengths to be included in appraisal outputs.	2.2.1 Verify Objective Evidence 2.2.2 Characterize Implementation of Model Practices 2.2.3 Validate Practice Implementation Gaps
	2.3 Document Objective Evidence	Create lasting records of the information gathered by identifying and then consolidating notes, transforming the data into records that document practice implementation, as well as strengths and weaknesses.	2.3.1 Take/Review/Tag Notes 2.3.2 Record Presence/Absence of Objective Evidence 2.3.3 Document Practice Implementation Gaps 2.3.4 Review and Update the Data Collection Plan
	2.4 Generate Appraisal Results	Rate goal satisfaction based upon the extent of practice implementation throughout the organizational unit. The extent of practice implementation is determined/judged based on validated data (e.g., the three types of objective evidence) collected from the entire representative sample of the organizational unit. The rating of capability levels and/or maturity levels is driven algorithmically by the goal satisfaction ratings.	2.4.1 Derive Findings and Rate Goals 2.4.2a Determine Process Area Capability Level 2.4.2b Determine Satisfaction of Process Areas 2.4.3a Determine Capability Profile 2.4.3b Determine Maturity Level 2.4.4 Document Appraisal Results

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The SCAMPI Process (cont'd)

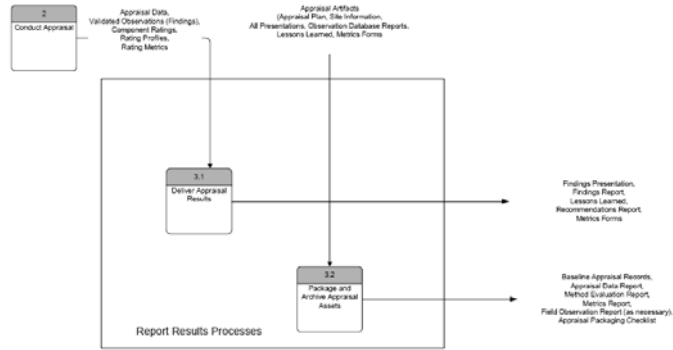| Phase	Process	Purpose	Activities
3 Report Results	3.1 Deliver Appraisal Results	Provide credible appraisal results that can be used to guide actions. Represent the strengths and weaknesses of the processes in use at the time. Provide ratings (if planned for) that accurately reflect the capability level/maturity level of the processes in use.	3.1.1 Present Final Findings 3.1.2 Conduct Executive Session(s) 3.1.3 Plan for Next Steps
	3.2 Package and Archive Appraisal Assets	Preserve important data and records from the appraisal, and dispose of sensitive materials in an appropriate manner.	3.2.1 Collect Lessons Learned 3.2.2 Generate Appraisal Record 3.2.3 Provide Appraisal Feedback to CMMI Steward 3.2.4 Archive and/or Dispose of Key Artifacts

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The SCAMPI Process – Control Flow

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The SCAMPI Process – Control Flow (cont'd)

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The SCAMPI Process – Control Flow (cont'd)

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SCAMPI – Nominal Assessment Schedule View
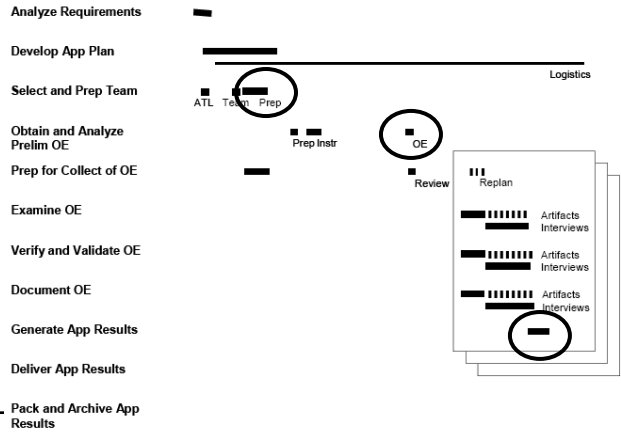
ATL = Appraisal Team Leader
OE = Objective Evidence

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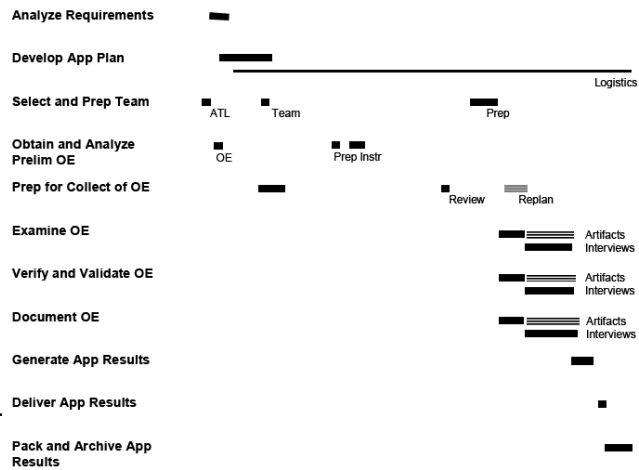
SCAMPI – Nominal Evaluation Schedule View

The basic difference between an assessment and an evaluation is that an assessment is an appraisal that an organization does to and for itself for the purposes of process improvement.

Assessments provide internal motivation for organizations to initiate or continue process improvement programs.
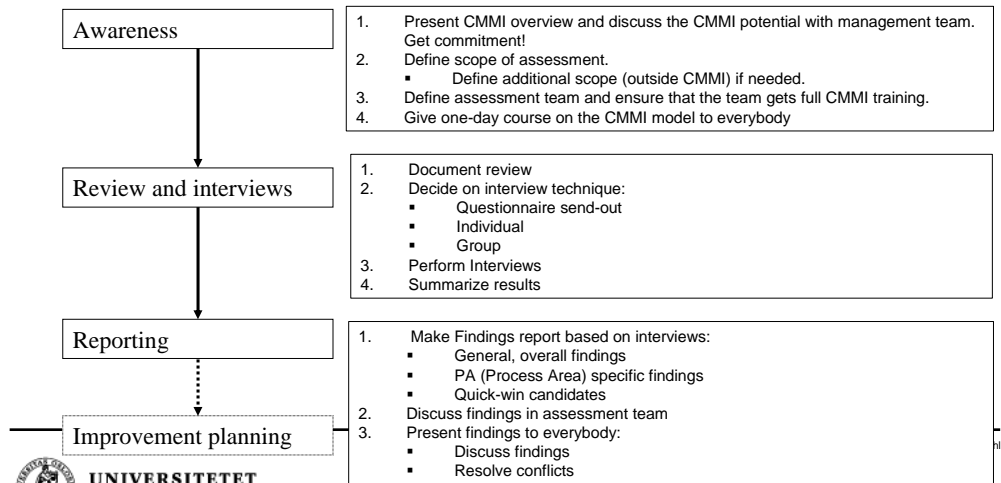
An evaluation is an appraisal in which an external group comes into an organization and examines its processes as input to a decision regarding future business. Evaluations are typically externally imposed motivation for organizations to undertake process improvement.

Analyze Requirements

Develop App Plan

Select and Prep Team
ATL   Team   Prep

Obtain and Analyze Prelim OE
Prep Instr   OE

Prep for Collect of OE
Review   Replan

Examine OE
Artifacts
Interviews

Verify and Validate OE
Artifacts
Interviews

Document OE
Artifacts
Interviews

Generate App Results

Deliver App Results

Pack and Archive App Results

Logistics

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A Simple Assessment-Process

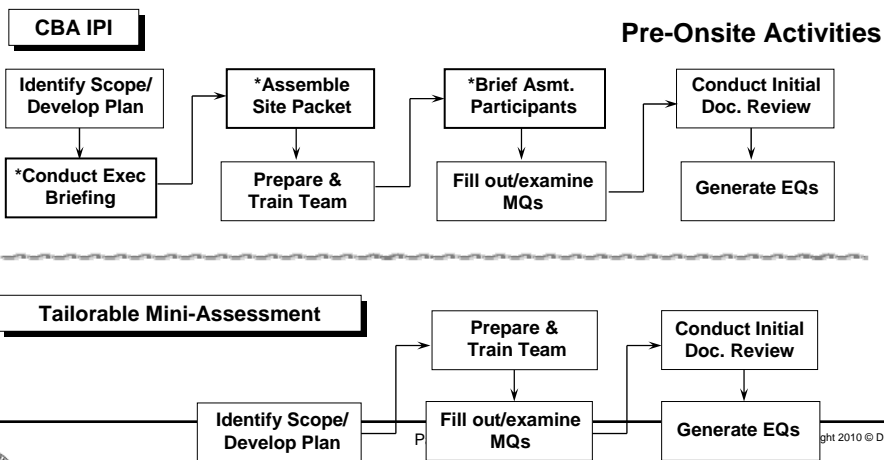| Awareness	1. Present CMMI overview and discuss the CMMI potential with management team. Get commitment! 2. Define scope of assessment. ▪ Define additional scope (outside CMMI) if needed. 3. Define assessment team and ensure that the team gets full CMMI training. 4. Give one-day course on the CMMI model to everybody

Review and interviews	1. Document review
	2. Decide on interview technique:
	    ▪ Questionnaire send-out
	    ▪ Individual
	    ▪ Group
	3. Perform Interviews
	4. Summarize results

Reporting	1. Make Findings report based on interviews:
	    ▪ General, overall findings
	    ▪ PA (Process Area) specific findings
	    ▪ Quick-win candidates
	2. Discuss findings in assessment team
	3. Present findings to everybody:
	    ▪ Discuss findings
	    ▪ Resolve conflicts

Improvement planning	

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Mini-Assessment Method

- An informal review of an organization's current software process based on:
  - A review of 3-4 key projects
    - responses to SEI's MQ (Maturity Questionnaire)
    - discussions with senior managers, project leaders, middle managers, and practitioners
    - document review

- Uses a tailored and streamlined version of the SEI's CBA IPI method
  - Cost and resource impacts reduced
    - less time, fewer participants, some sessions combined or deleted, less formality
  - No ratings
  - Focuses on global strengths and high priority issues
    - primarily weaknesses at the KPA level

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CBA IPI & Mini-Assessment Comparison

CBA IPI   **Pre-Onsite Activities**

| Identify Scope/ Develop Plan | *Assemble Site Packet | *Brief Asmt. Participants | Conduct Initial Doc. Review |
| *Conduct Exec Briefing | Prepare & Train Team | Fill out/examine MQs | Generate EQs |

Tailorable Mini-Assessment

| | Prepare & Train Team | Conduct Initial Doc. Review |
| Identify Scope/ Develop Plan | Fill out/examine MQs | Generate EQs |

*Asterisked (red items) are omitted during a mini-assessment.
EQs=Exploratory Questions   MQs=Maturity Questionnaires

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CBA IPI & Mini-Assessment Comparison

Onsite Activities

| CBA IPI | → | Interview Managers | → | Consolidate Info | → | Prep. Draft Findings | → | Pres. Final Findings |

Conduct Opening Mtg. → Interview PLs → *Consolidate Info → *Pres. Draft Findings → Conduct Exec Mtg./Wrapup

Interview FARs → *Consolidate Info → *Consol/Rate/Prep Final Findings

Tailorable Mini-Assessment
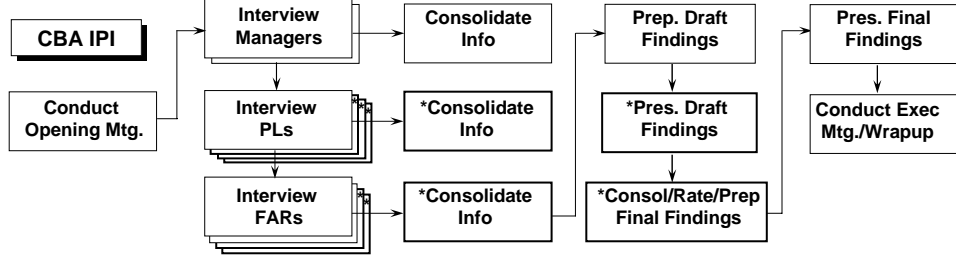
Notes: *Asterisked (red) items are omitted during a mini-assessment.
Managers=Senior & Middle Mgrs.   PLs=Project Leads   FARs=Functional Area Reps

Conduct Opening Mtg. → Interview PLs → Consolidate Info → Pres. Final Findings

Interview Managers → Interview FARs → Prep. Draft Findings → Conduct Exec Mtg./Wrapup

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Mini-Assessment Status Chart (optional)

SOFTWARE PROJECT PLANNING							
	Commitment to Perform	Ability to Perform	Activities Performed				Measurement & Analysis	Verifying Implementation
			1	2	3	4		

Common Feature Definitions:

Commitment to Perform:	documented policy, senior management commitment demonstrated, responsibilities assigned
Ability to Perform:	adequate resources (tools, staff, $) to perform the practices, role/function in place, trained personnel
Activities Performed:	1. processes/template documented & used 2. estimates, commitments, & schedules generated/documented 3. project plans complete & documented, 4. risks (technical & program) identified
Measurement & Analysis:	process metrics collected & analyzed
Verifying Implementation:	process activities reviewed by senior management, middle management, & SQA

Compliance Legend:

	Practices implemented and institutionalized (in place on all assessed projects)
	Some practices implemented. Or practices performed only some projects (inconsistent across the organization).
	Little or no evidence of practices in place (on the assessed projects).

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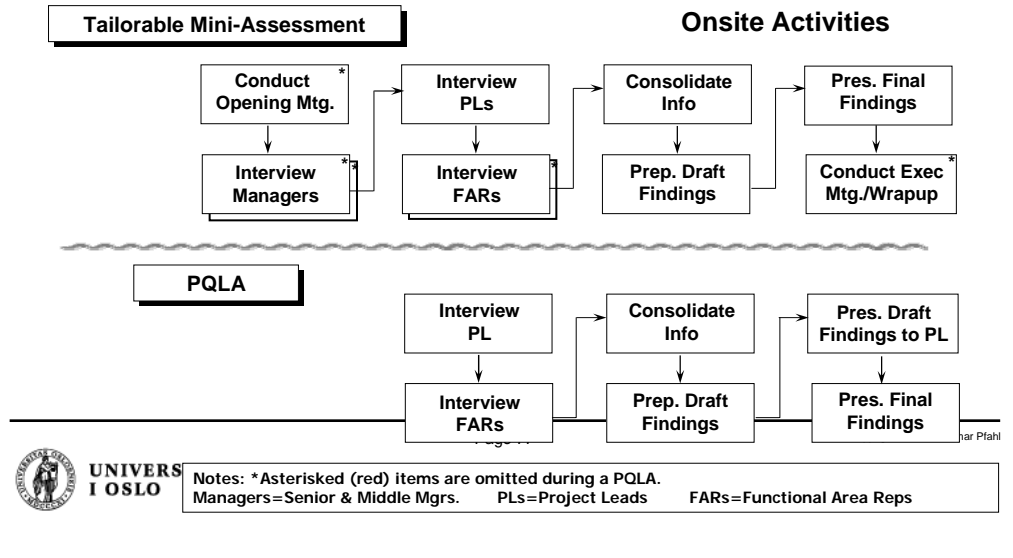
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Project Quick Look Assessment Method

- An informal review of a single project's current software process based on:
  - Discussions with Project Lead and practitioners
  - Document review
- Uses a tailored and streamlined version of the mini-assessment method
  - Cost and resource impacts greatly reduced
    - minimal time, fewer participants, some sessions combined or deleted, informal discussions and briefing
  - Reduced scope
    - single project only; no organizational practices evaluated
  - Interview questions more direct and interactive
  - No ratings
  - Focuses on high priority issues at the KPA level

PQLA approach developed and successfully used at General Dynamics

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Mini-Assessment & PQLA Comparison

Tailorable Mini-Assessment   **Pre-Onsite Activities**

```
                              Prepare &          Conduct Initial
                              Train Team         Doc. Review
          Identify Scope/     *Fill out/Exam.    Generate EQs
          Develop Plan        MQs
```

PQLA

```
                              Prepare &          Conduct PL
                              Train Team         pre-interview
          Identify Scope/     Conduct Initial    Generate EQs
          Develop Plan        Doc. Review
```

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*Asterisked (red items) are omitted during a PQLA
EQs=Exploratory Questions   MQs=Maturity Questionnaires   PL=Project Lead

Mini-Assessment & PQLA Comparison

Tailorable Mini-Assessment   **Onsite Activities**

| Conduct Opening Mtg. * | → | Interview PLs | → | Consolidate Info | → | Pres. Final Findings |

| Interview Managers *| | Interview FARs *| | Prep. Draft Findings | | Conduct Exec Mtg./Wrapup *|

PQLA

| Interview PL | → | Consolidate Info | → | Pres. Draft Findings to PL |

| Interview FARs | | Prep. Draft Findings | | Pres. Final Findings |

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Notes: *Asterisked (red) items are omitted during a PQLA.
Managers=Senior & Middle Mgrs.   PLs=Project Leads   FARs=Functional Area Reps

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CMMI^{sm} Classes of Assessment Methods

Comparison with CMM Assessment Methods

Class A:
• Full comprehensive method
• Thorough model coverage
• Provides maturity level
SCAMPI

Class B:
• Less comprehensive, less expensive
• Initial, partial, self-assessment
• Focus on areas needing attention
• No maturity level rating

Class C:
• Quick look
• Checking for specific risk areas
• Inexpensive, little training needed

CBA IPI

Mini-Assessment

PQLA

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SCAMPI = Standard CMMI Assessment Method for Internal Process Improvement.
sm CMM Integration and CMMI are service marks of Carnegie Mellon University.

Assessment Method Comparisons

	CBA IPI	Mini-asmt.	PQLA
*Resources:			
- # team members	**6-8**	**4-6**	**4**
- team member time (plan, prep, conduct)	**110-130 hrs.**	**48-60 hrs.**	**14-20 hrs.**
- # participants	**50-60**	**30-40**	**8-10**
- participant time (prep, conduct)	**4-8 hrs.**	**2-5 hrs.**	**1-3 hrs.**
Team training (CMM and assessment method)	**5 days**	**1.5-2 days**	**4-6 hrs.**
Pre On-Site schedule (wall time)	**2-3 months**	**3-4 weeks**	**1 week**
On-Site schedule (consecutive days)	**7-9 days**	**4-5 days**	**1.5-2 days**
Formality (briefings, plans, reports, paperwork)	**• Formal** **• Maximum doc. review**	**• Informal** **• Moderate doc. review**	**• Very informal** **• Minimal doc. review**

*Resources are per person; Typical figures for an organization with size 100 SW staff, covering Levels 2 & 3.
Total time includes planning, preparing, and conducting.

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Assessment Method Comparisons (cont.)

		CBA IPI	Mini-assessment	PQLA

Outputs		**• Findings briefing:**
		  - Global findings
		  - KPA findings (strengths & weaknesses)
		  - Maturity Level
		  - KPA ratings
		• Final Report
		• Data/results to SEI
			• Findings briefing:
			  - Global findings
			  - KPA findings (strengths & weaknesses)
			• Color chart (opt)
				• Findings briefing:
				  - Global findings
				  - KPA weaknesses

Pros		**• Very comprehensive / accurate** **• Supports detailed action plan**	**• Comprehensive** **• Reliable predictor of CBA IPI results** **• Less time, $, participants, tension**	**• Minimal time, $, participants** **• Participants more at ease; interactive**
Cons		**• Expensive** **• Time consuming** **• Schedule difficulties** **• Tension due to ratings**	**• Schedule difficulties**	**• Some weaknesses may be missed** **• Does not provide organizational view**

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Interim Evaluation – CMM-Mini

- A light weight evaluation for projects and line organization – developed by KDA

- Tool: a spreadsheet that lists all relevant KPAs with its practices

- All practices are given a score:
  - y – Yes
  - p – Partly
  - n – Not
  - na – Not Applicable

- Assumes that mapping to procedures and documents (PIIDs) has been done in advance.

- Project:
  - All KPAs and all practices which are relevant for the project (all in level 2 plus a selection in level 3)
  - Are implemented regularly (every or every other month)
  - Are based on 1 full review (< 8 hours), while the other is focused (< 2 hours)

- Line: A selection of KPAs on level 3 where the responsibility is centralized.

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Example: Requirement Management

Requirements Management

Goals for the RM Key Process Area:

Goal 1: System requirements allocated to software are controlled to establish a baseline for software engineering and management use.

Goal 2: Software plans, products and activities are kept consistent with the system requirements allocated to software.

Key practices		Values	Assess the status in the "Values" column; y=yes, p=partly, n=no	How is it handled within the project?	Solutions provided from the line organization	Action required to achieve compliance?
c	1	y	The project follows a written organizational policy for managing the allocated system requirements.		KDA Quality Manual, part I SE-process and INS 0234	
ab	1	y	For each project, responsibility is established for analysing the system requirements and allocating them to HW, SW, and other system components	Responsibility (Role) defined and allocated to a person or group.	KDA Roles: SE-manager responsible for allocating requirements to SW, HW etc. SW architect responsible for writing the SRS.	
ab	2	y	The allocated requirements are documented.	Technical, Non-technical requirements and acceptance criteria are defined and documented!	SE-process: User Requirement specification (URS), System Segment Specification (SSS), Interface requirement specification (IRS), Software Requirement Specification (SRS), Hardware development specification (HDS), Statement of Work (SOW) INS 0234	
ab	3	y	Adequate resources and funding are provided for managing the allocated requirements.	An agreement written between the line and project for the allocated RM resources. Hours for RM planned, Necessary tools available.	A2DS tool: Rational Requisite Pro	
ab	4	y	Members of the engineering group and other related groups are trained to perform their requirements management activities.	Training in RM activities both technical application, methods and tools. Example Prephase training.		
ac	1	y	The engineering group reviews the allocated requirements before they are incorporated into the project.		PRO-0017 Review Process. SRS checklist in PRO-0016. A2DS Requirements to projects: Requirements handling.	
ac	2	y	The engineering group uses the allocated requirements as the basis for plans, work products, and activities.		Project management process, Initial planning PRO-0015 Software Engineering Management, Plan the SW development uses SRSs as input to planning. A2DS Task descriptions?	

CMM-Mini Results (project)

| Total CMMI Complience: | 63 % | | Tailoring: Use of Not Applicable: | 8 % |
| CMMI Level 2 complience: | 77 % | | CMMI Level 3 complience: | 22 % |

CMMI Level 2/3

Legend:
- Negative
- Partly
- Not Applicable
- Positive

X-axis: Total, REQM, PP, PMC, SAM, MA, PPQA, CM, RD, TS, PI, VER, VAL, IPM, RSKM, DAR, ISM*, IT**

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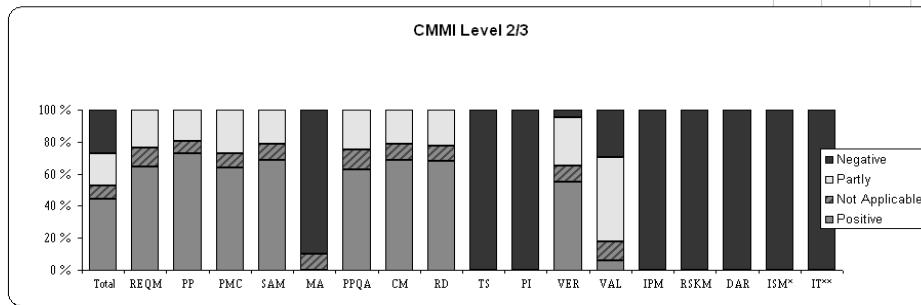
Assessment Follow-On Activities
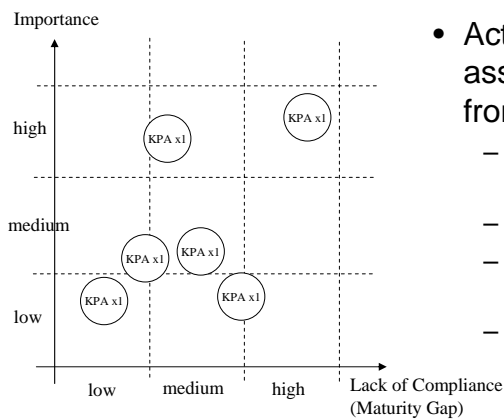
- Action plan – generated by SEPG, assessment team, and key personnel from organization/projects
  - Address findings (how to address weaknesses)
  - Strategy for addressing additional KPAs
  - Detailed actions, responsibilities, budget, and schedule
  - Reviewed/approved by management

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and …

CONTINUOUS PROCESS IMPROVEMENT

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SEI Slogan

"The Capability Maturity Model for Software (CMM) is a framework that describes the elements of an effective software process.

The CMM describes an evolutionary path
from an ad hoc, chaotic process,
to a mature disciplined process"

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CMMI as a Roadmap

- It is not difficult to come up with a long list with good proposals for improvements.
- It is more difficult to prioritize the most important and to make a realistic progress plan.
- The most difficult of all is to manage the necessary changes in the organization – work pattern and not the least culture.

This is the way to the destination

← This is my destination

I am here

✕ CMM(I) assessment

◯ Project evaluation (post-mortem)/ experience meetings

◯ CMM-Mini

◯ QA Audits

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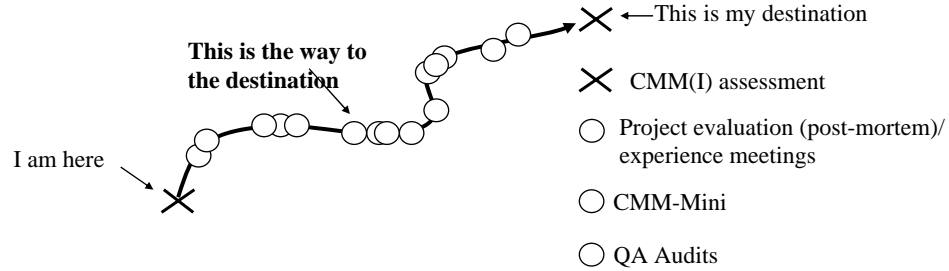
Process Improvement: IDEAL

The Process Improvement Process of SEI:

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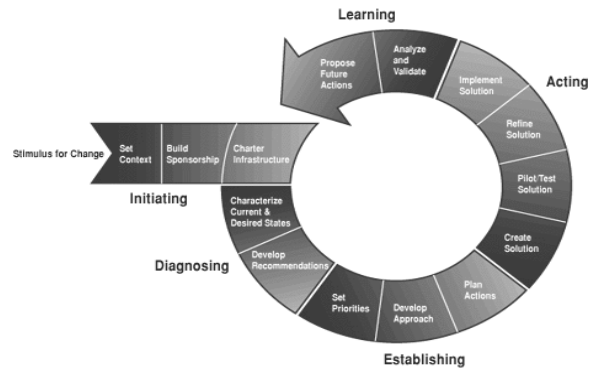
CMM and QIP

- CMM is well suited to be used with Quality Improvement Paradigm on the organizational level
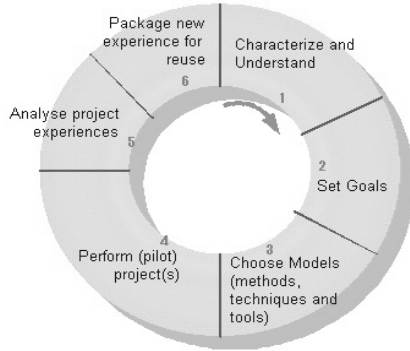
1. **Conduct a CMM-assessment. Combine the results with business goals and identified problems.**

2. **Use "Findings" from the assessment to define improvement goals**

3. Choose measures which are supposed to help achieve the objectives

4. Implement one or more projects with the new models, tools and methods. Collect data on the way

5. Collect lessons learnt from the projects

6. Update standard process model and experience database

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PROFES –
**Product-Focused
Process Improvement
in Software Engineering**

The PROFES improvement cycle
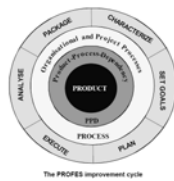
PROFES PHASES	PROFES STEPS
CHARACTERIZE	1. VERIFY COMMITMENT
	2. IDENTIFY PRODUCT QUALITY NEEDS
	3. DETERMINE CURRENT PRODUCT QUALITY
	4. DETERMINE CURRENT PROCESS CAPABILITY
SET GOALS	5. SET PRODUCT IMPROVEMENT GOALS
	6. DETERMINE NECESSARY PROCESS CHANGES
PLAN	7. DESCRIBE PROCESS CHANGES
	8. SET METRICS FOR THE PROCESSES AND PRODUCT
	9. PREPARE IMPROVEMENT IMPLEMENTATION
EXECUTE	10. IMPLEMENT AND MONITOR IMPROVEMENTS
ANALYSE	11. EVALUATE RESULTS
PACKAGE	12. UPDATE EXPERIENCE BASE

Phases and steps of the PROFES improvement methodology

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Step 5 Set product improvement goals

Goals	Activities
• Set Product improvement goals	• Analyse product quality discrepancies
	• Identify product improvement areas
	• Prioritize product improvement areas
	• Set the product improvement goals

Input	Output
Business goals	• Product improvement goals
Product quality needs	
• Product quality target profile	
• Current status of product quality	
• Process assessment reports and profiles	
• Descriptive process models	
• Preliminary product quality goals	
• Product characteristics	

Step 6 Determine necessary process changes

Goals	Activities
• Identify and select process changes necessary to achieve the product improvement goals.	• Identify product quality goal
• Document the decisions on necessary process changes for later evaluation of the improvement programme	• Identify processes to be improved
	• Retrieve relevant PPD models
	• Construct characterization questionnaire
	• Characterize the project
	• Rank PPD models
	• Select improvement actions

Input	Output
• Product improvement goals	• Process changes to be implemented in the improvement programme
• Process assessment reports and profiles (from Step 4)	• Characterization of the forthcoming project or improvement programme
• PPD repository	
• Preliminary improvement plan (from Step 4)	

Step 7 Describe process changes

Goals	Activities
• Agree and document prescriptive process model	• Mark processes/practices in the current process model, which have to be changed
• Achieve clear understanding of the processes in order to define the metrics in the following step	• Develop prescriptive process model
	• Communicate prescriptive process model to process participants

Input	Output
• Descriptive process model (from Step 4)	• Prescriptive process model (including selected process changes)
• Selected list of process changes (from Step 6)	• Training/presentation material for the new process

Step 8 Set metrics for the processes and product improvements

Goals	Activities
• Define questions and metrics related to the product quality goals	• Define measurement goals
• Define questions and metrics related to the process performance goals	• Conduct GQM interviews
• Define questions and metrics related to the product-process dependency goals	• Define questions and hypotheses
• Construct GQM plan and measurement plan	• Define and check metrics
	• Produce GQM plan and measurement plan

Input	Output
• Prescriptive process model (including selected process changes)	• GQM abstraction sheets
• Product quality and target profile (from Step 2)	• GQM plan
• Current status of product quality (from Step 3)	• Measurement plan
• Product improvement goals (from Step 5)	
• Process assessment reports and profiles (from Step 4)	
• PPD models (from Step 6)	

Step 9 Prepare improvement implementation

Goals	Activities
• Plan process changes and allocate sufficient resources to implement them	• Plan process improvement progress meetings
• Plan improvement progress meetings	• Make time planning and resource allocation
	• Kick-off process changes

Input	Output
• Development project plan	• Process improvement action plan
• Preliminary improvement plan (from Step 4)	• On-line process support
• Selected list of process changes (from Step 6)	
• Prescriptive process model (from Step 7)	
• GQM deliverables (from Step 8)	

Step 10 Implement and monitor improvements in the development project

Goals	Activities
• Implement selected process changes according to process improvement plan	• Implement process changes
• Collect data and prepare measurement results for each feedback session	• Collect measurement data
• Hold feedback sessions	• Prepare and select measurement data
	• Perform GQM feedback sessions

Input	Output
• Prescriptive process model	• Measurement data
• GQM plan	• Feedback session report(s) with visualized measurement data
• Measurement plan	• Description of corrective actions taken
• Process improvement plan	• Prescriptive process model applied in practice
• Development project plan	

Step 11 Evaluate Results

Goals	Activities
• Evaluate effect of the improvement programme on final product quality	• Evaluate the measurement results
• Evaluate changes to the software engineering process, methods, and tools	• Support, modify, or reject used PPD models
• Gather and evaluate "lessons learned"	
• Support, modify, or reject used PPD models	

Input	Output
• PPD models	• Preliminary experience packages
• Prescriptive process model	• Evaluated PPD models
• Abstraction sheets	
• GQM plan	
• GQM measurement plan	
• Measurement data	
• Feedback session reports	

Step 12 Update Experience Base

Goals	Activities
• Package and store all information gained during the project in the experience base for future reuse	• Package information
	• Store relevant information in the experience base

Input	Output
• Evaluated PPD models	• Updated experience base with generalized:
• Experience base	• PPD models
• Process models	• Process models
• GQM plan	• GQM plans
• Feedback session reports	

Different Process Improvement Approaches

- Most users of CMM(I) today use it internally as a improvement framework – i.e. they don't intend to use assessment results for marketing purpose.

- The most active CMM advocates (Mark Paulk and Bill Curtis) strongly warn against following the model blindly. *Use the model with common sense, coupled with understanding one's own needs and problem areas.*

Model-less SPI (e.g. GQM)	CMM(I) used as guideline (combined with GQM/QIP or similar)	"Hard-core CMM" (SCAMPI)

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Use Common Sense...

- Mark Paulk, SEI:

Process Discipline

		Yes	No
Common Sense	**Yes**	Quality	Creative Chaos
	No	Mindless Bureaucracy	Mindless Chaos

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CMMI ®

DISSEMINATION and RESULTS

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Improvements According to SEI Data

Performance Results of CMMI®-Based Process Improvement

The quantitative performance results in Table 2 are from a total of 35 organizations, some of which are enterprises with more than one constituent organization. 30 of them have results that can be expressed as change over time. These results are expressed either as percentage change from an earlier baseline prior to the CMMI-based process improvement or as ratios of return on investment (ROI). The results are summarized by the six performance categories discussed in Section 2 of this document: cost, schedule, productivity, quality, customer satisfaction and return on investment. Most of the organizations have provided multiple results, sometimes several in the same performance category.

TECHNICAL REPORT
CMU/SEI-2006-TR-004
ESC-TR-2006-004

Table 2:   CMMI Performance Results Summary

Performance Category	Median Improvement	Number of Data Points		Lowest Improvement	Highest Improvement
Cost	34%	29		3%	87%
Schedule	50%	22		2%	95%
Productivity	61%	20		11%	329%
Quality	48%	34		2%	132%
Customer Satisfaction	14%	7		-4%	55%
Return on Investment	4.0 : 1	22		1.7 : 1	27.7 : 1

Note: The performance results in this table express change over varying periods of time.

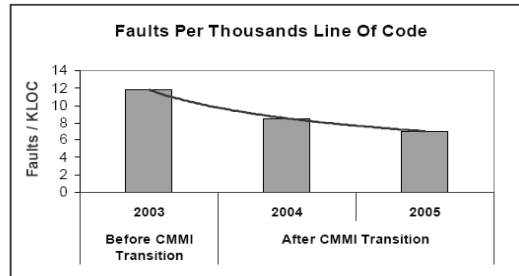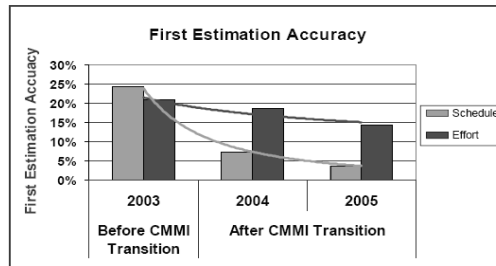**UNIVERSITETET I OSLO**

Motorola GSG China

Figure 24: In Process Faults per Thousand Lines of Code

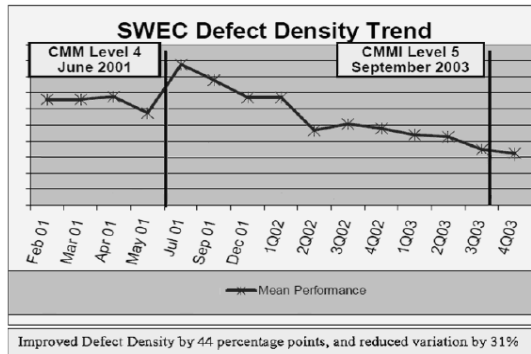**UNIVERSITETET I OSLO**

Raytheon Network Centric Systems

SWEC Defect Density Trend

CMM Level 4
June 2001

CMMI Level 5
September 2003

Feb 01 Mar 01 Apr 01 May 01 Jul 01 Sep 01 Dec 01 1Q02 2Q02 3Q02 4Q02 1Q03 2Q03 3Q03 4Q03

Mean Performance

Improved Defect Density by 44 percentage points, and reduced variation by 31%

Figure 40: Defect Density

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Telcordia (CMM)

Telcordia Field Fault Density

Faults per thousand function points

47.3　40.2　28.5　9.2　7.2　3.3　2.6

1993　1994　1995　1996　1997　1998　1999

Pitterman (2000)

TeraQuest　© 2000　　　20　　　PROFES'00 21 June 2000

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Boeing

Results: Effort Estimation

140%

0 %

-140%

Over/Under Percentage

Without Historical Data
Variance between + 20% to - 145%
(Mostly Level 1 & 2)

With Historical Data
Variance between - 20% to + 20%
(Level 3)

(Based on 120 projects in Boeing Information Systems)

Page 99

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Reference: John D. Vu. "Software Process
Improvement Journey:From Level 1 to Level 5."
7th SEPG Conference, San Jose, March 1997.

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Status and Spread of CMMI

- **SCAMPI v1.1 Class A appraisals conducted since its April 2002 release and reported to the SEI by July 2004**
  - 367 **appraisals**
  - 333 **organizations**
  - 176 **participating companies**
  - 28 **reappraised organizations**
  - 1.368 **projects**
  - 46,2 % **Non-USA organizations**

Organization Type
Based on Primary Standard Industrial Classification (SIC) Code

Page 100

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