Course "Softwareprozesse"

Process Improvement: CMMI

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Part 1:

- Process improvement, TQM, CMMI
- The 5 CMMI Levels
- CMMI elements:
  - goals, practices
- The 22 CMMI process areas

Part 2:

- Generic goals and practices
- Continuous representation
- Benefits from CMMI introduction
- Practical advice

Learning objectives

- Understand the purpose and structure of the CMMI
- Know the maturity levels and their process areas
- Learn to use CMMI as a reference framework for assessing and understanding software processes

Basic assumption of process improvement

Assumption:

When developing or building a complex product,

the quality of the final product

is determined to a large degree

by the quality of the process used.

- This assumption is plausible for software development, because its activities tend to become so complex that even the most capable engineers cannot handle it well if the process is not well organized

Historical notes

- ~1920: Walter Shewhart introduces *Statistical Process Control* at Western Electric
- ~1950-1960: William Edwards Deming pioneers continuous process improvement for industrial production in Japan
  - Similar work was performed by Joseph Juran and Armand Feigenbaum
  - This eventually led to what is now known as TQM (Total Quality Management)
  - ~1980: Deming presents his *14 points* (key principles for management) and *7 deadly diseases*
- 1986: Watts Humphrey and the Software Engineering Institute publish the Capability Maturity Model for Software (CMM-SW)
  - other CMMs follow (e.g. people, systems engineering) and are now combined in CMMI

Deming

Humphrey

Deming/TQM versus CMMI

- Deming's ideas and TQM are aimed at industrial *production* (manufacturing)
  - They are generic for all kinds of products
  - They pay much attention to general human factors
  - They focus on process, not product

- In contrast, CMMI is aimed at intellectual work
  - CMMI-DEV (formerly called CMMI-SW/SE) is specific to software and systems *development*
    - but for all kinds of software or HW/SW systems
    - There is also a CMMI-SVC for services
    - There is also a CMMI-ACQ for acquisition

- Like TQM, CMMI also pays attention to human factors
- Like TQM, CMMI also focuses on process, not product

Summary of Deming's 14 points

- Cease dependence on mass inspection to achieve quality.
  - Instead, improve the process and build quality into the product in the first place. (Feasible for production, hard for development)
- Adopt a new philosophy of cooperation (win-win).
  - Drive out fear and build trust.
  - Break down barriers between departments.
- Adopt and institute leadership for the management of people,
  - recognizing their different abilities, capabilities, and aspiration.
  - Institute training for skills.
  - Institute a vigorous program of education and self-improvement.
- Create constancy of purpose
  - for the improvement of product and service.
  - Improve constantly.
- Put everybody in the company to work to accomplish the transformation.

Basic idea of CMMI-DEV

- All high-quality software processes need to solve the same fundamental kinds of process problems
- These problems can be described in terms of
  - **process areas** and
  - **goals**
- Approaches that help solve the problems can be described in terms of
  - **practices** (describing WHAT to do, not HOW)
- These goals need to be achieved one by one.
  - Some orderings of goal-achievement are easier than others.
  - This is described by introducing **maturity levels**

- CMMI captures and represents a body of experience about useful areas, goals, practices, and goal orders.

The CMMI maturity levels

Example: A process area and its goals

- One of the process areas is *Requirements Management (REQM)*
  - others are for instance *Project Planning (PP)*, *Validation (VAL)*, or *Quantitative Project Management (QPM)*
- Requirements Management is assigned to Level 2 (Managed)
  - while for instance *Quantitative Project Management* is on Level 4

Requirements Management has four goals:

- **Specific goal** SG1: Manage requirements
  - (Specific goals are particular to one process area)
- **Generic goal** GG1: Achieve Specific Goals
  - (Generic goals apply to all process areas)
- Generic goal GG2: Institutionalize a Managed Process
- Generic goal GG3: Institutionalize a Defined Process

Example (2): A goal and its practices

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Specific goal SG1: Manage requirements

- "*Requirements are managed and inconsistencies with project plans and work products are identified.*"

Specific practices for this goal:

- SP 1.1 Understand 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 Ensure Alignment Between Project Work and Requirements

Example (3): Refinements of a practice

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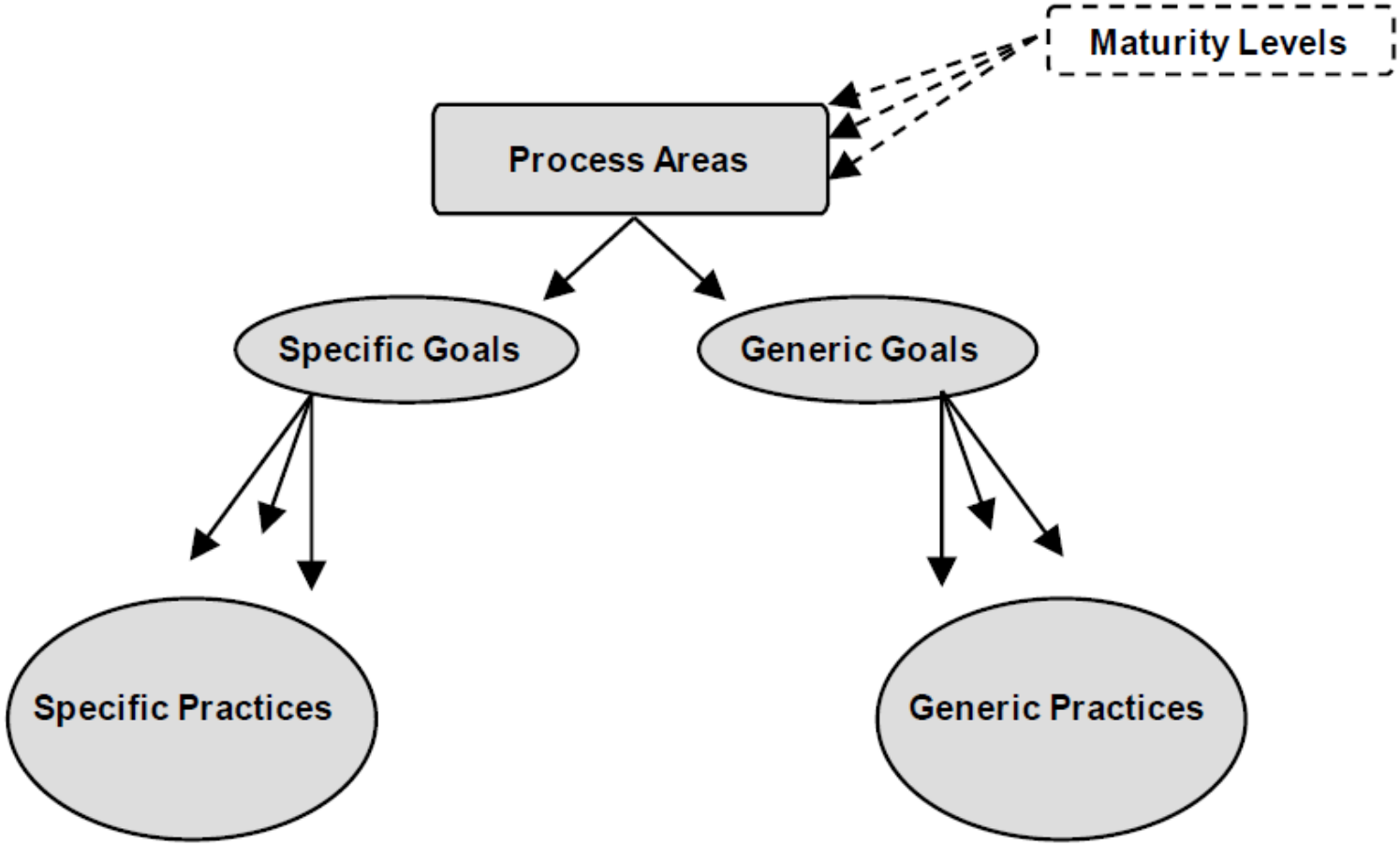
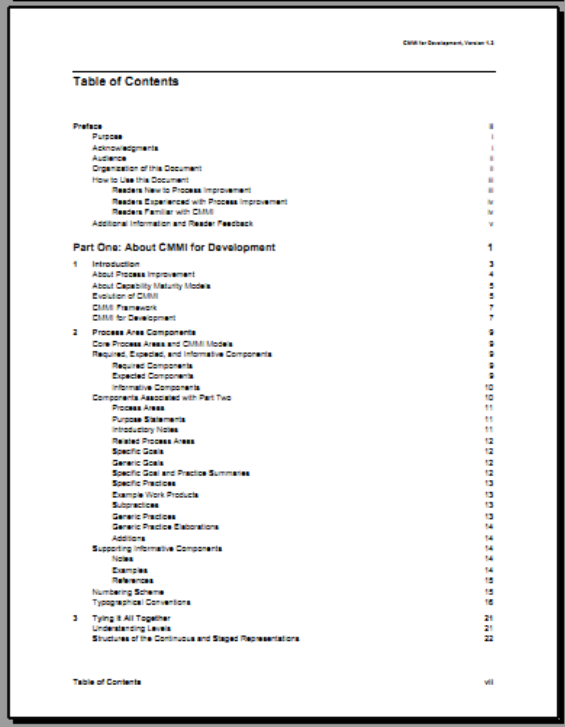
Process area Requirements Management

- Specific goal SG 1: Manage Requirements
  - **Specific practice SP 1.3 Manage Requirements Changes:** *"Manage changes to the req's as they evolve during the project."*
    - Typical **work products**:
      - Requirements status
      - Requirements database
      - Requirements change requests and change impact reports
    - **Subpractices**:
      - Document all requirements and requirements changes that are given to or generated by the project.
      - Maintain requirements change history with change rationale and make them available to the project.
      - Evaluate the impact of requirement changes from the standpoint of relevant stakeholders.
      - Make req's and change data available to the project.

Structure of the staged CMMI



The *staged* version of CMMI.
There is also a *continuous* version.



CMMI for Development, Version 1.3

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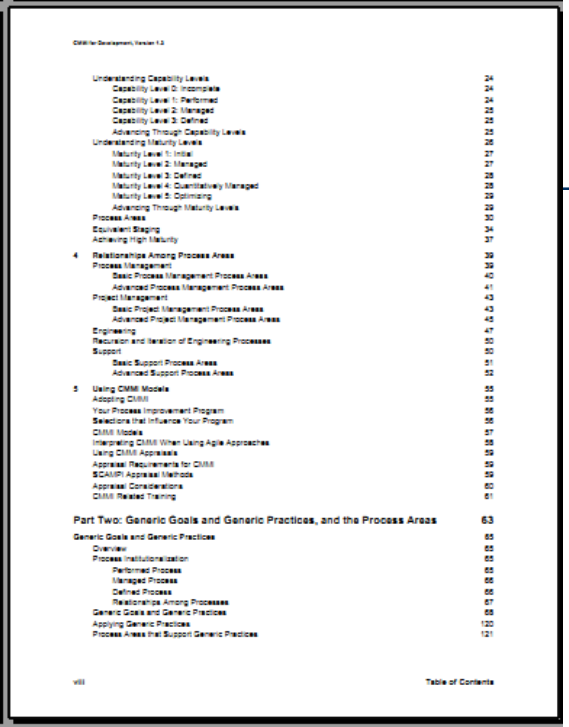

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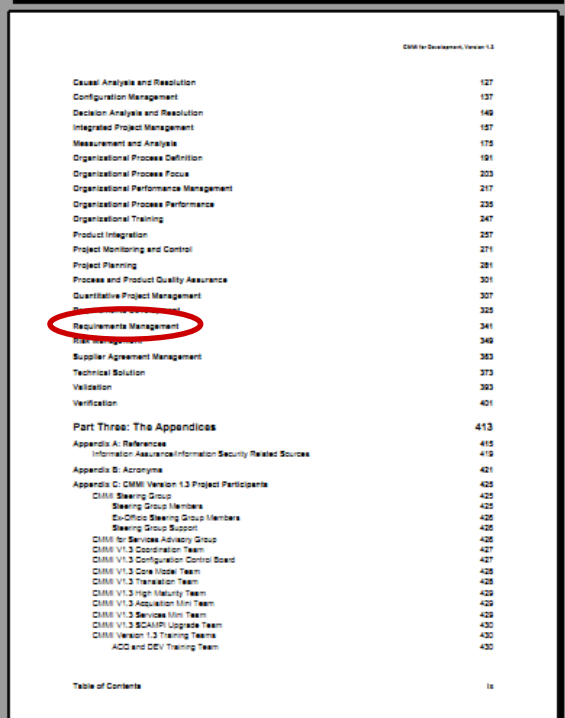

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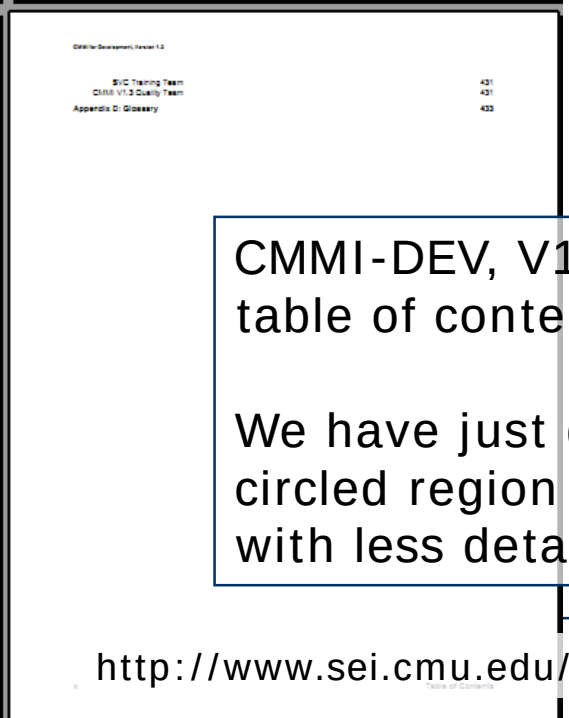

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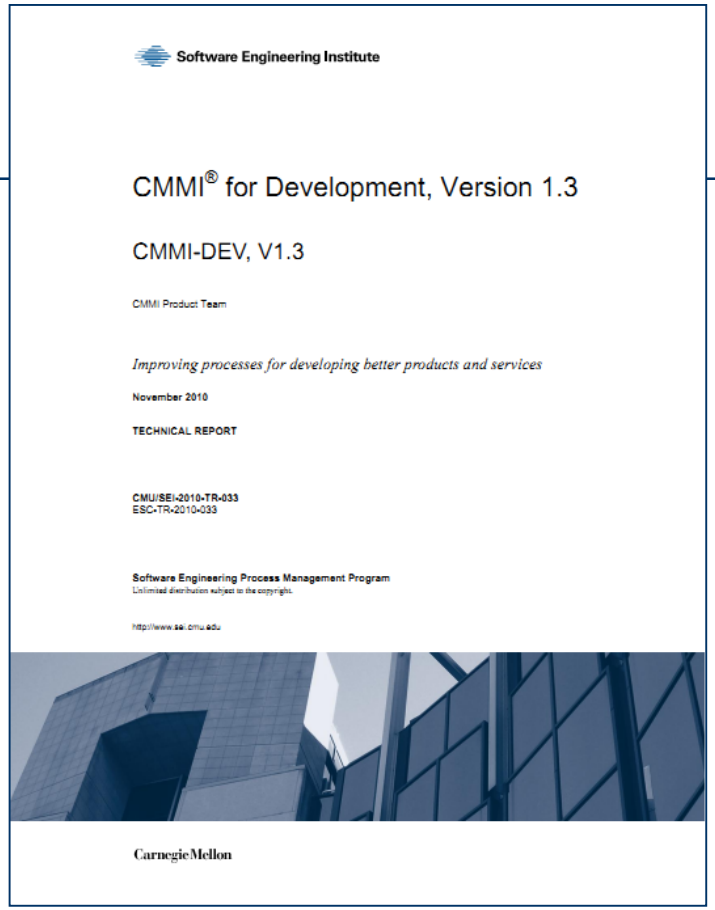

Software Engineering Institute

CMMI® for Development, Version 1.3

CMMI-DEV, V1.3

CMMI Product Team

Improving processes for developing better products and services

November 2010

TECHNICAL REPORT

CMU/SEI-2010-TR-033
ESC-TR-2010-033

Software Engineering Process Management Program
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http://www.sei.cmu.edu

Carnegie Mellon

CMMI-DEV, V1.3
table of contents (480 pages total)

We have just discussed ~30% of the circled region only (and will proceed with less detail).

http://www.sei.cmu.edu/library/abstracts/reports/10tr033.cfm

Required, expected, and informative elements

- An organization can have its maturity level certified
  - by a process called process appraisal or process assessment
- But only the goals described for a level are mandatory
  - the goals are *required* model elements
- while the practices are only *'expected'*
  - for a given organization, an alternative practice or even a non-implemented practice may be acceptable.

- Furthermore, CMMI also contains *'informative'* elements.
  - For instance typical work products, sub-practices, notes.
  - These may be helpful knowledge, but are purely optional.

The 22 CMMI process areas

- **Level 2: Managed**
  - Requirements Mgmt REQM
  - Project Planning PP
  - Project Monitoring&Control PMC
  - Supplier Agreement Mgmt SAM
  - Measurement and Analysis MA
  - Process and Product Quality Assurance PPQA
  - Configuration Management CM
- Level 3: Defined
  - Req's. Development REQD
  - Technical Solution TS
  - Product Integration PI
  - Verification VER
  - Validation VAL
  - Organizational Process Focus OPF
  - Organ'l Process Definition OPD
  - Organizational Training OT
  - Integrated Project Mgmt. IPM
  - Risk Management RSKM
  - Decision Analysis and Resolution DAR
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  - Organizational Process Performance OPP
  - Quantitative Project Mgmt QPM
- Level 5: Optimizing
  - Organizational Performance Management OPM
  - Causal Analysis and Resolution CAR

7 + 11 + 2 + 2 process areas

Process Area Categories

Engineering

Support

Project Management

Process Management

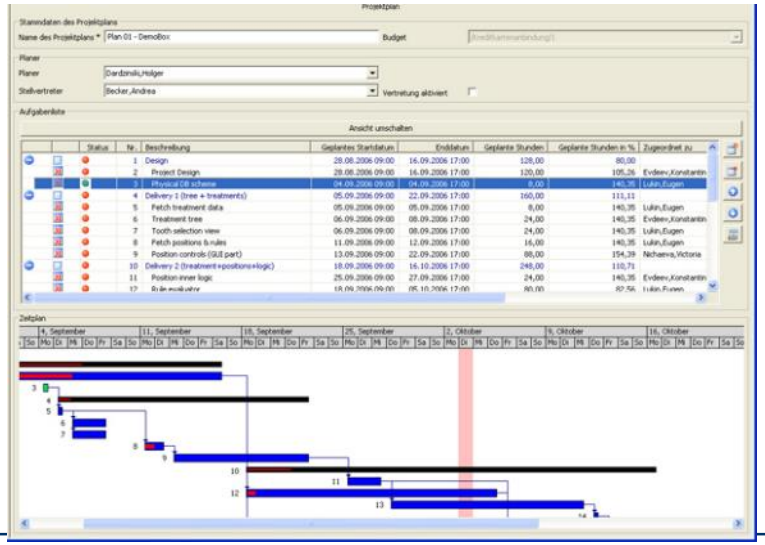
Requirements Management, REQM

- SG1 Manage requirements
  - SP 1.1 Understand 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 Ensure Alignment Between Project Work and Requirements

- Often the most important/useful process area overall

Project Planning, PP

- SG 1 Establish Estimates
  - SP 1.1 Establish the Scope of the Project
  - SP 1.2 Establish Estimates of Work Product and Task Attributes
  - SP 1.3 Define Project Lifecycle Phases
  - SP 1.4 Estimate Effort and Cost
- SG 2 Develop a Project Plan
  - SP 2.1 Establish the Budget and Schedule
  - SP 2.2 Identify Project Risks
  - SP 2.3 Plan Data Management
  - SP 2.4 Plan the Project's Resources
  - SP 2.5 Plan Needed Knowledge and Skills
  - SP 2.6 Plan Stakeholder Involvement
  - SP 2.7 Establish the Project Plan
- SG 3 Obtain Commitment to the Plan
  - SP 3.1 Review Plans That Affect the Project
  - SP 3.2 Reconcile Work and Resource Levels
  - SP 3.3 Obtain Plan Commitment



https://de.wikipedia.org/wiki/Datei:Screen_Project_Plan.jpg

Project Monitoring & Control, PMC

- SG 1 Monitor the Project Against the Plan
  - SP 1.1 Monitor Project Planning Parameters
  - SP 1.2 Monitor Commitments
  - SP 1.3 Monitor Project Risks
  - SP 1.4 Monitor Data Management
  - SP 1.5 Monitor Stakeholder Involvement
  - SP 1.6 Conduct Progress Reviews
  - SP 1.7 Conduct Milestone Reviews
- SG 2 Manage Corrective Action to Closure
  - SP 2.1 Analyze Issues
  - SP 2.2 Take Corrective Action
  - SP 2.3 Manage Corrective Action

- Bad PMC invalidates even the best PP

Supplier Agreement Mgmt, SAM

- SG 1 Establish Supplier Agreements
  - SP 1.1 Determine Acquisition Type
  - SP 1.2 Select Suppliers
  - SP 1.3 Establish Supplier Agreements
- SG 2 Satisfy Supplier Agreements
  - SP 2.1 Execute the Supplier Agreement
  - SP 2.2 Accept the Acquired Product
  - SP 2.3 Ensure Transition of Products

- Relevant not just for subcontracting but also for selecting standard software
  - such as DBMS, middleware, critical development tools etc.

Measurement and Analysis, MA

- SG 1 Align Measurement and Analysis with Objectives
  - SP 1.1 Establish Measurement Objectives
    - Very important step!
  - SP 1.2 Specify Measures
  - SP 1.3 Specify Data Collection and Storage Procedures
  - SP 1.4 Specify Analysis Procedures
- SG 2 Provide Measurement Results
  - SP 2.1 Obtain Measurement Data
  - SP 2.2 Analyze Measurement Data
  - SP 2.3 Store Data and Results
  - SP 2.4 Communicate Results

- MA is hardly useful on Level 2
  but is an important foundation for Level 3

Process and Product Quality Assurance, PPQA

- SG 1 Objectively Evaluate Processes and Work Products
  - SP 1.1 Objectively Evaluate Processes
  - SP 1.2 Objectively Evaluate Work Products
    - Work products are checked against the process description, not the project's requirements (→ **do not confuse this with *Validation***)
- SG 2 Provide Objective Insight
  - SP 2.1 Communicate and Resolve Noncompliance Issues
  - SP 2.2 Establish Records

- Warning: PPQA will lead to 'process police' and resistance if planned processes are inadequate
  - PPQA is useful only if and where the expected process is also a sensible and suitable process
    - Less is often more

Configuration Management, CM

- SG 1 Establish Baselines
  - SP 1.1 Identify Configuration Items
  - SP 1.2 Establish a Configuration Management System
  - SP 1.3 Create or Release Baselines
- SG 2 Track and Control Changes
  - SP 2.1 Track Change Requests
  - SP 2.2 Control Configuration Items
- SG 3 Establish Integrity
  - SP 3.1 Establish Configuration Management Records
  - SP 3.2 Perform Configuration Audits

- What this means is <u>very</u> project-dependent

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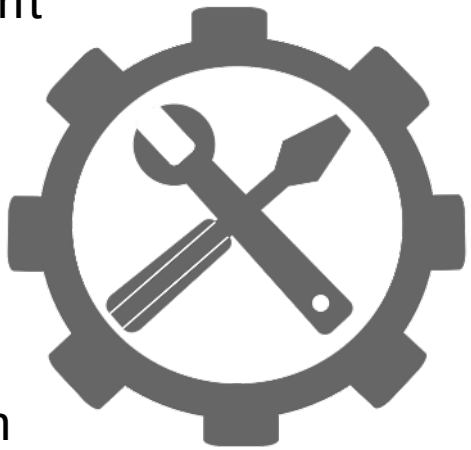
Req's. Development, REQD

- SG 1 Develop Customer Requirements
  - SP 1.1 Elicit Needs
  - SP 1.2 Transform 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
- 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
    - needed?, sufficient?, conflict?
  - SP 3.4 Analyze Req's to Achieve Balance
  - SP 3.5 Validate Requirements

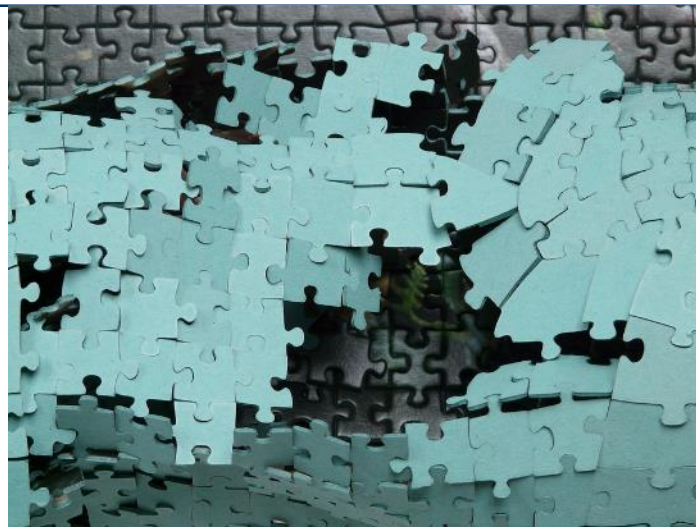
Technical Solution, TS

- SG 1 Select Product-Component Solutions
  - SP 1.1 Develop Alternative Solutions and Selection Criteria
  - SP 1.2 Select Product-Component Solutions
- SG 2 Develop the Design
  - SP 2.1 Design the Product or Product Component
  - SP 2.2 Establish a Technical Data Package
  - SP 2.3 Design Interfaces Using Criteria
  - SP 2.4 Perform Make/Buy/Reuse Analyses
- SG 3 Implement the Product Design
  - SP 3.1 Implement the Design
  - SP 3.2 Develop Product Support Documentation



- TS is roughly what is commonly called *design* (in particular architecture and make/buy decisions) and *implementation*

Product Integration, PI



- SG 1 Prepare for Product Integration
  - SP 1.1 Establish an Integration Strategy
  - SP 1.2 Establish the Product Integration Environment
  - SP 1.3 Establish Product Integration Procedures and Criteria
- SG 2 Ensure Interface Compatibility
  - SP 2.1 Review Interface Descriptions for Completeness
  - SP 2.2 Manage Interfaces
- SG 3 Assemble Product Components and Deliver the Product
  - SP 3.1 Confirm Readiness of Product Components for Integration
  - SP 3.2 Assemble Product Components
  - SP 3.3 Evaluate Assembled Product Components
  - SP 3.4 Package and Deliver the Product or Component

- PI is a major aspect of what is commonly called *testing*

Verification, VER

- SG 1 Prepare for Verification
  - SP 1.1 Select Work Products for Verification
    - including verification methods
  - SP 1.2 Establish the Verification Environment
  - SP 1.3 Establish Verification Procedures and Criteria
- SG 2 Perform Peer Reviews
  - SP 2.1 Prepare for Peer Reviews
  - SP 2.2 Conduct Peer Reviews
  - SP 2.3 Analyze Peer Review Data
    - about Preparation, Conduct, and Results
- SG 3 Verify Selected Work Products
  - SP 3.1 Perform Verification
  - SP 3.2 Analyze Verification Results

- "The purpose of Verification is to ensure that selected work products meet their specified requirements."

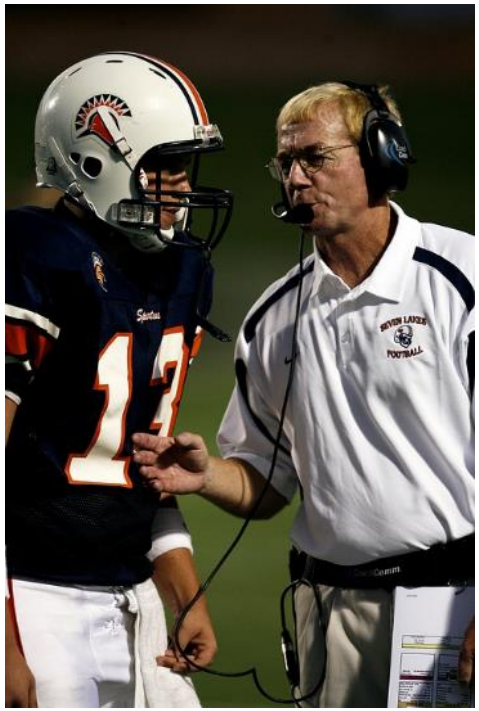
Validation, VAL

- SG 1 Prepare for Validation
  - SP 1.1 Select Products for Validation
    - including validation methods
  - SP 1.2 Establish the Validation Environment
  - SP 1.3 Establish Validation Procedures and Criteria
- SG 2 Validate Product or Product Components
  - SP 2.1 Perform Validation
  - SP 2.2 Analyze Validation Results

- "Demonstrate that a product or product component fulfills its intended use when placed in its intended environment (such as operation, training, maintenance, support)."
  - So VAL is against user requirements (whether explicit or implicit) while VER is against product requirements and specifications

Organizational Process Focus, OPF

- SG 1 Determine Process-Improvement Opportunities
  - SP 1.1 Establish Organizational Process Needs
  - SP 1.2 Appraise the Organization's Processes
  - SP 1.3 Identify the Org.'s Process Improvements
- SG 2 Plan and Implement Process Actions
  - SP 2.1 Establish Process Action Plans
  - SP 2.2 Implement Process Action Plans
- SG 3 Deploy Organ'l Process Assets & Incorporate Experiences
  - SP 3.1 Deploy Organizational Process Assets
  - SP 3.2 Deploy Standard Processes
  - SP 3.3 Monitor the Implementation
  - SP 3.4 Incorporate Experiences into the Organizational Process Assets



- This establishes constructive quality assurance as a potentially *ongoing activity*

Organizational Process Definition, OPD

- SG 1 Establish Organizational Process Assets
  - SP 1.1 Establish Standard Processes
  - SP 1.2 Establish Lifecycle Model Descriptions
  - SP 1.3 Establish Tailoring Criteria and Guidelines
  - SP 1.4 Establish the Organization's Measurement Repository
  - SP 1.5 Establish the Organization's Process Asset Library
  - SP 1.6 Establish Work Environment Standards
  - SP 1.7 Establish Rules and Guidelines for Teams

- Lifts many Level-2 practices from project-specific forms to organization-wide standards
  - optimizes their quality, saves resources

- Like PPQA, this can lead to 'process police' and resistance if applied improperly.
  - Again, less is often more

Organizational Training, OT

- SG 1 Establish an Organizational Training Capability
  - SP 1.1 Establish Strategic Training Needs
  - SP 1.2 Determine Which Training Needs Are the Responsibility of the Organization
    - as Opposed to Project or Support Group
  - SP 1.3 Establish an Organizational Training Tactical Plan
  - SP 1.4 Establish Training Capability
- SG 2 Provide Training
  - SP 2.1 Deliver Training
  - SP 2.2 Establish Training Records
  - SP 2.3 Assess Training Effectiveness

Integrated Project Mgmt., IPM

- SG 1 Use the Project's Defined Process
  - SP 1.1 Establish the Project's Defined Process
  - SP 1.2 Use Organizational Process Assets for Planning Project
  - SP 1.3 Establish the Project's Work Environment
  - SP 1.4 Integrate Plans
    - Extends Project Planning PP to include defined process
  - SP 1.5 Manage the Project Using Integrated Plans
  - SP 1.6 Establish Teams
  - SP 1.7 Contribute to the Organizational Process Assets
    - Work Products, Measurements, and Experiences
- SG 2 Coordinate and Collaborate with Relevant Stakeholders
  - SP 2.1 Manage Stakeholder Involvement
  - SP 2.2 Manage Dependencies
    - What is important for which stakeholder when?
  - SP 2.3 Resolve Coordination Issues
- IPM is most important in the context of HW+SW engineering.

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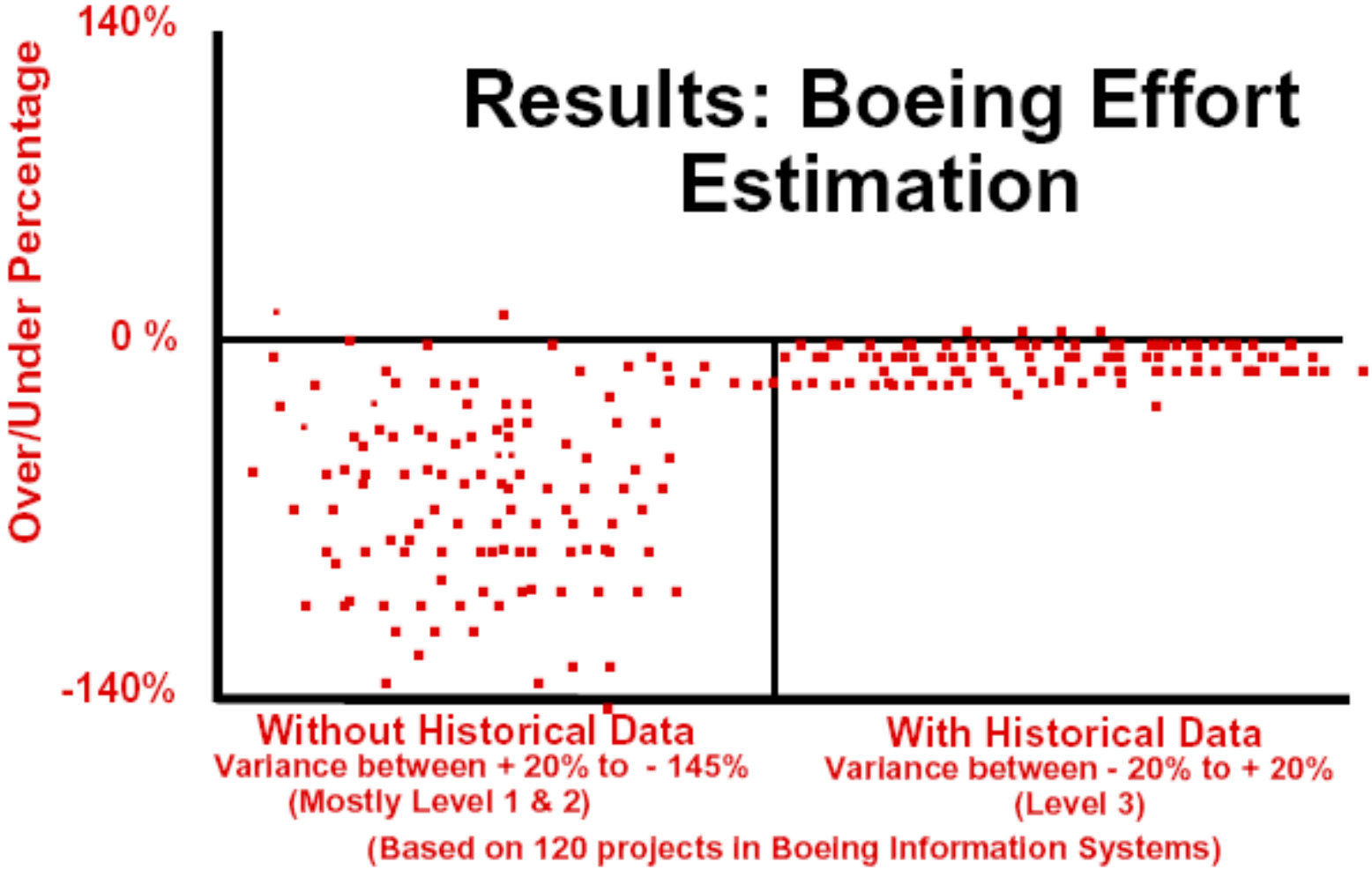
CMMI Results: Effort estimation accuracy



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

Risk Management, RSKM

- SG 1 Prepare for Risk Management
  - SP 1.1 Determine Risk Sources and Categories
  - SP 1.2 Define Risk Parameters
  - SP 1.3 Establish a Risk Management Strategy
- SG 2 Identify and Analyze Risks
  - SP 2.1 Identify Risks
  - SP 2.2 Evaluate, Categorize, and Prioritize Risks
- SG 3 Mitigate Risks
  - SP 3.1 Develop Risk Mitigation Plans
  - SP 3.2 Implement Risk Mitigation Plans

Decision Analysis and Resolution, DAR

- SG 1 Evaluate Alternatives
  - SP 1.1 Establish Guidelines for Decision Analysis
  - SP 1.2 Establish Evaluation Criteria
  - SP 1.3 Identify Alternative Solutions
  - SP 1.4 Select Evaluation Methods
  - SP 1.5 Evaluate Alternative Solutions
    - using criteria and methods
  - SP 1.6 Select Solutions

- The idea behind DAR:
  - A formal evaluation process reduces the subjectivity of the decision and so
  - has a higher probability of selecting a solution that meets the multiple demands of the relevant stakeholders.

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Organ'l Process Performance, OPP

- SG 1 Establish Performance Baselines and Models
  - SP 1.1 Select Quality and Process Performance Objectives
    - "What is important for us?"
  - SP 1.2 Select Processes
    - "Which parts are worth measuring?"
  - SP 1.3 Establish Process Performance Measures
    - "Which measures tell us how good we are?"
  - SP 1.4 Analyze Process Performance and Establish Process Performance Baselines
    - "How good are we typically in process X today?"
  - SP 1.5 Establish Process Performance Models
    - "How does process performance change when other observable factors change?"
    - Examples: System dynamics models, Reliability growth models, Complexity models

Quantitative Project Mgmt, QPM

- SG 1 Prepare for Quantitative Managment
  - SP 1.1 Establish the Project's Objectives
  - SP 1.2 Compose the Defined Process
    - Select subprocesses based on performance objectives and existing performance data relative to the project requirements
  - SP 1.3 Select the Subprocesses and Attributes
  - SP 1.4 Select Measures and Analytic Techniques
- SG 2 Quantitatively Manage the Project
  - SP 2.1 Monitor the Performance of the Selected Subprocesses
  - SP 2.2 Manage Project Performance
  - SP 2.3 Perform Root Cause Analysis

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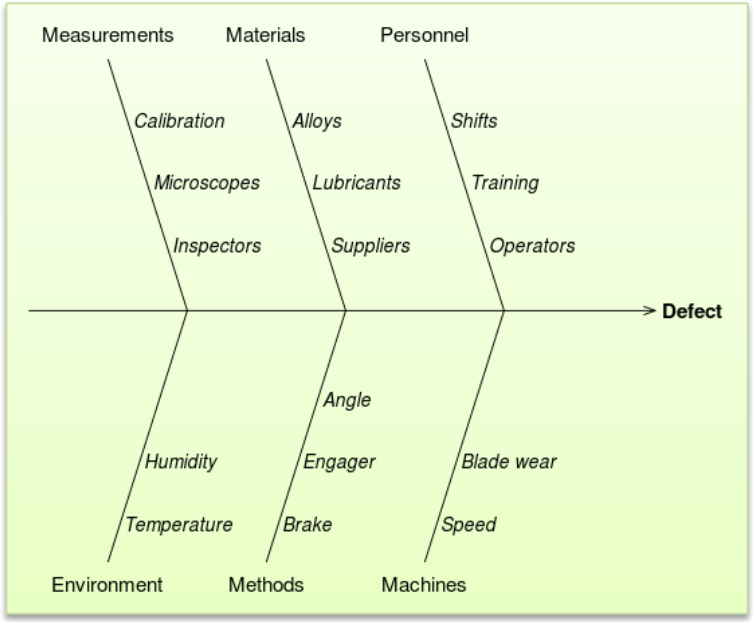
Organ'l Performance Management, OPM [formerly OID]

- SG 1 Manage Business Performance
  - SP 1.1 Maintain Business Objectives
  - SP 1.2 Analyze Process Performance Data
  - SP 1.3 Identify Potential Areas for Improvement
- SG 2 Select Improvements
  - SP 2.1 Elicit Suggested Improvements
  - SP 2.2 Analyze Suggested Improvements
  - SP 2.3 Validate Improvements
  - SP 2.4 Select and Implement Improvements for Deployment
- SG 3 Deploy Improvements
  - SP 3.1 Plan the Deployment
  - SP 3.2 Manage the Deployment
  - SP 3.3 Evaluate Improvement Effects

- In contrast to Organizational Process Focus OPF, OPM is based on quantitative management

Causal Analysis and Resolution, CAR

- SG 1 Determine Causes of Selected Outcomes
  - SP 1.1 Select Outcomes for Analysis
    - such as defects
  - SP 1.2 Analyze Causes
    - Root Cause Analysis, plus Action Proposals
- SG 2 Address Causes of Selected Outcomes
  - SP 2.1 Implement Action Proposals
  - SP 2.2 Evaluate the Effect of Implemented Actions
  - SP 2.3 Record Causal Analysis Data



- CAR can be applied to any process quality attribute ("outcome"), not just product defects

The 22 CMMI process areas

- Level 2: Managed
  - Requirements Mgmt REQM
  - Project Planning PP
  - Project Monitoring&Control PMC
  - Supplier Agreement Mgmt SAM
  - Measurement and Analysis MA
  - Process and Product Quality Assurance PPQA
  - Configuration Management CM
- Level 3: Defined
  - Req's. Development REQD
  - Technical Solution TS
  - Product Integration PI
  - Verification VER
  - Validation VAL
  - Organizational Process Focus OPF
  - Organ'l Process Definition OPD
  - Organizational Training OT
  - Integrated Project Mgmt. IPM
  - Risk Management RSKM
  - Decision Analysis and Resolution DAR
- Level 4: Quantitatively Manag'd
  - Organizational Process Performance OPP
  - Quantitative Project Mgmt QPM
- Level 5: Optimizing
  - Organizational Performance Management OPM
  - Causal Analysis and Resolution CAR

Support	*Proc. Mgmt.*
Proj. Mgmt.	*Engineering*

Process areas are connected

E.g. the introduction to the **REQM** process area states:

- *Refer to the Requirements Development process area (**REQD**) for more information about eliciting, analyzing, and establishing customer, product, and product component requirements.*
- *Refer to **TS** for transforming selecting, designing, and implementing solutions to requirements.*
- *Refer to **PP** for establishing and maintaining plans that define project activities.*
- *Refer to **CM** regarding establishing baselines and tracking and controlling changes.*
- *Refer to **PMC** for more information about monitoring the project against the plan and managing corrective action to closure.*
- *Refer to **RSKM** regarding identifying and handling risks associated with requirements.*

REQM, PP and CM are Level 2 areas, the others are Level 3.

Similar cross references exist in each process area.

End of part 1

The 22 CMMI process areas

- Level 2: Managed
  - Requirements Mgmt REQM
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  - Project Monitoring&Control PMC
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  - Organizational Process Performance OPP
  - Quantitative Project Mgmt QPM
- Level 5: Optimizing
  - Organizational Performance Management OPM
  - Causal Analysis and Resolution CAR

- **Each process area has its own specific goals (SG)**
  - **and specific practices (SP)**

Generic goals

Remember?: Requirements Management has four goals:

Specific goal SG1: Manage requirements

- Specific goals are particular to one process area

Generic goal GG1: Achieve Specific Goals

- Generic goals apply to all process areas

Generic goal GG2: Institutionalize a Managed Process

Generic goal GG3: Institutionalize a Defined Process

- The generic goals and practices enable the organization to **institutionalize** specific best practices.
  - There are only these three generic goals, GG1, GG2, GG3
    - but many generic practices
  - Institutionalization is a key idea of CMMI, realized at level 3

Generic practice GP2.1 (for GG2)

Generic goal <u>GG2</u>: Institutionalize a Managed Process

Generic Practices

Commitment to Perform:

- GP 2.1 Establish and maintain an organizational policy for planning and performing the process.
  - Senior management should define organizational expectations for this process

Generic practices GP 2.2 to 2.5

Ability to Perform:

- GP 2.2 Plan the process
  - Plan contains: process description (activities, dependencies, result requirements, quality/performance objectives), resources needed, assignment of responsibilities, training description, monitoring/measurement/review requirements, stakeholder involvement
- GP 2.3 Provide adequate resources for performing the process
  - Funding, facilities, skilled people
- GP 2.4 Assign responsibility and authority
  - Confirm that the people assigned to the responsibilities and authorities understand and accept them.
- GP 2.5 Train people
  - by self-study, formalized on-the-job training, classroom training.

2.3, 2.4, 2.5 are often neglected!

Generic practices GP 2.6 to 2.8

Directing Implementation:

- GP 2.6 Control work products
  - cf. Configuration Management CM process area
- GP 2.7 Identify and Involve the Relevant Stakeholders
- GP 2.8 Monitor and Control the Process
  - measure and review performance
  - identify deviations and problems and take&track corrective action

Generic practices GP 2.9 to 2.10

Verifying Implementation:

- GP 2.9 Objectively evaluate adherence of the process and address noncompliance
  - Evaluation by people external to the process
  - cf. Process and Product Quality Assurance PPQA process area
    - but PPQA is performed by the project team whereas GP 2.9 is performed by a process improvement group
    - separate GP 2.9 & PPQA exist because CMMI targets large organizations
- GP 2.10 Review process status with higher level management and resolve issues

Generic practices GP 3.1/3.2 (for GG3)

Generic goal GG3: Institutionalize a Defined Process

Generic Practices

Commitment to Perform:

- GP 3.1 Establish and maintain the description of a defined process
  - tailored from the organization's set of standard processes to address the needs of a specific instantiation

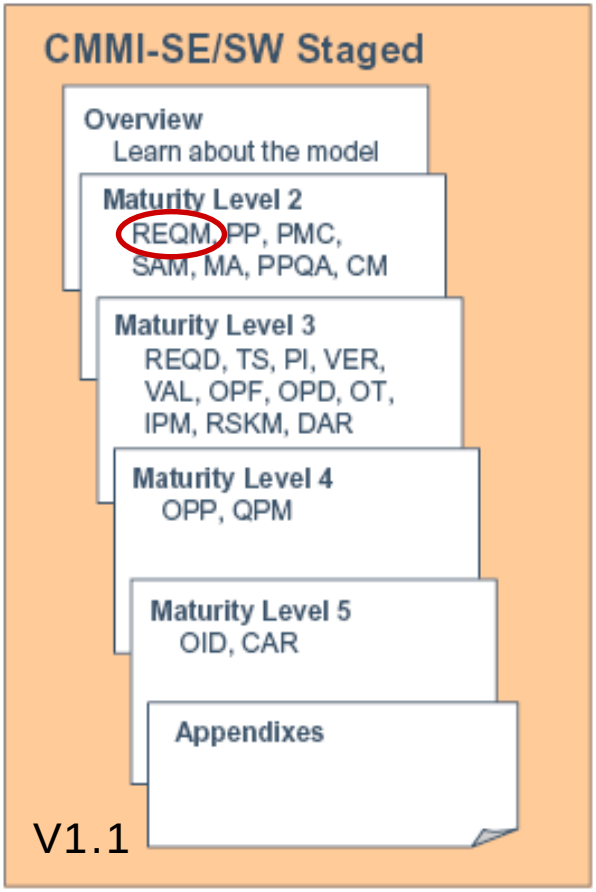
Directing Implementation:

- GP 3.2 Collect Process-Related Experiences
  - e.g. effort expended for the various activities, defects injected or removed in a particular activity, and lessons learned.
    - Valuable for Level 4, Level 5, and Process Tailoring

Reminder: REQM Generic practices

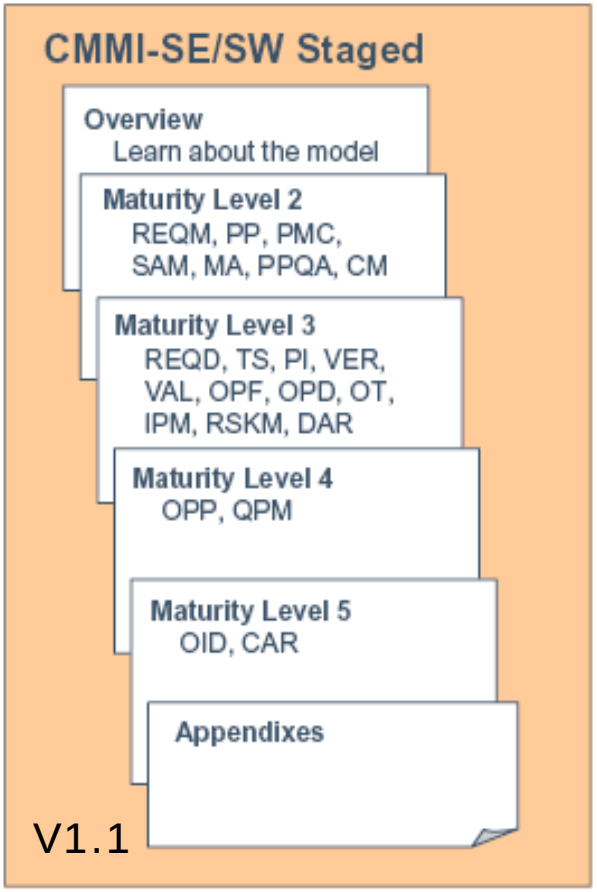
- All of the generic practices previously seen apply to process area Requirements Management (REQM)
  - because they all apply to each Level-2 process area
- Some apply to the institutionalization of REQM on Level 2
  - those numbered GP 2.x
- others apply to REQM only when the organization moves on towards Level 3
  - those numbered GP 3.x

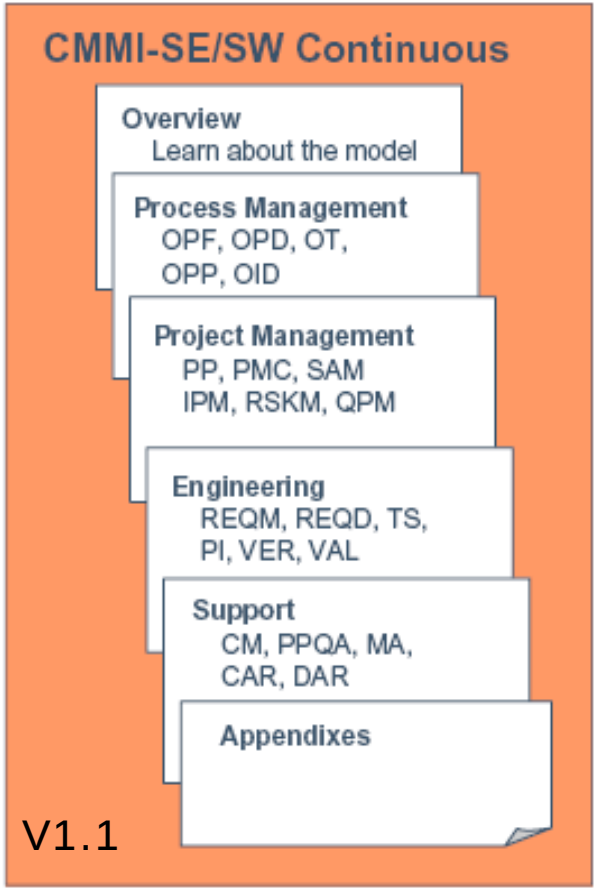
(And likewise for all other process areas)



Alternative representation: continuous

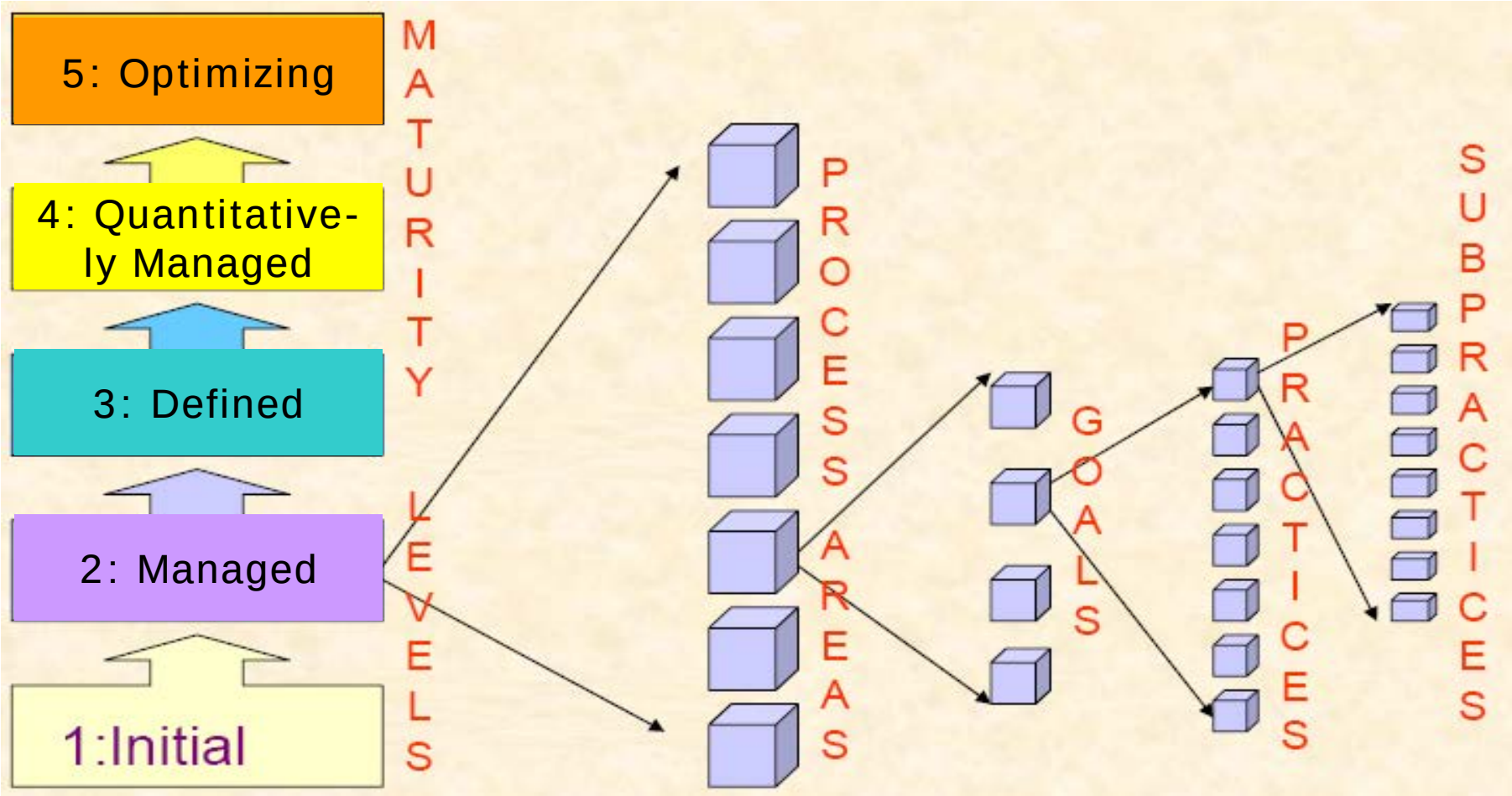
- In many cases, the maturity levels are overly rigid
  - Organizations may have good reasons for focusing on only a few process areas, rather than all of a maturity level
- Therefore, there is an alternative representation of the same process areas, specific goals, and specific practices
  - called the **continuous representation**
  - using thematic groups





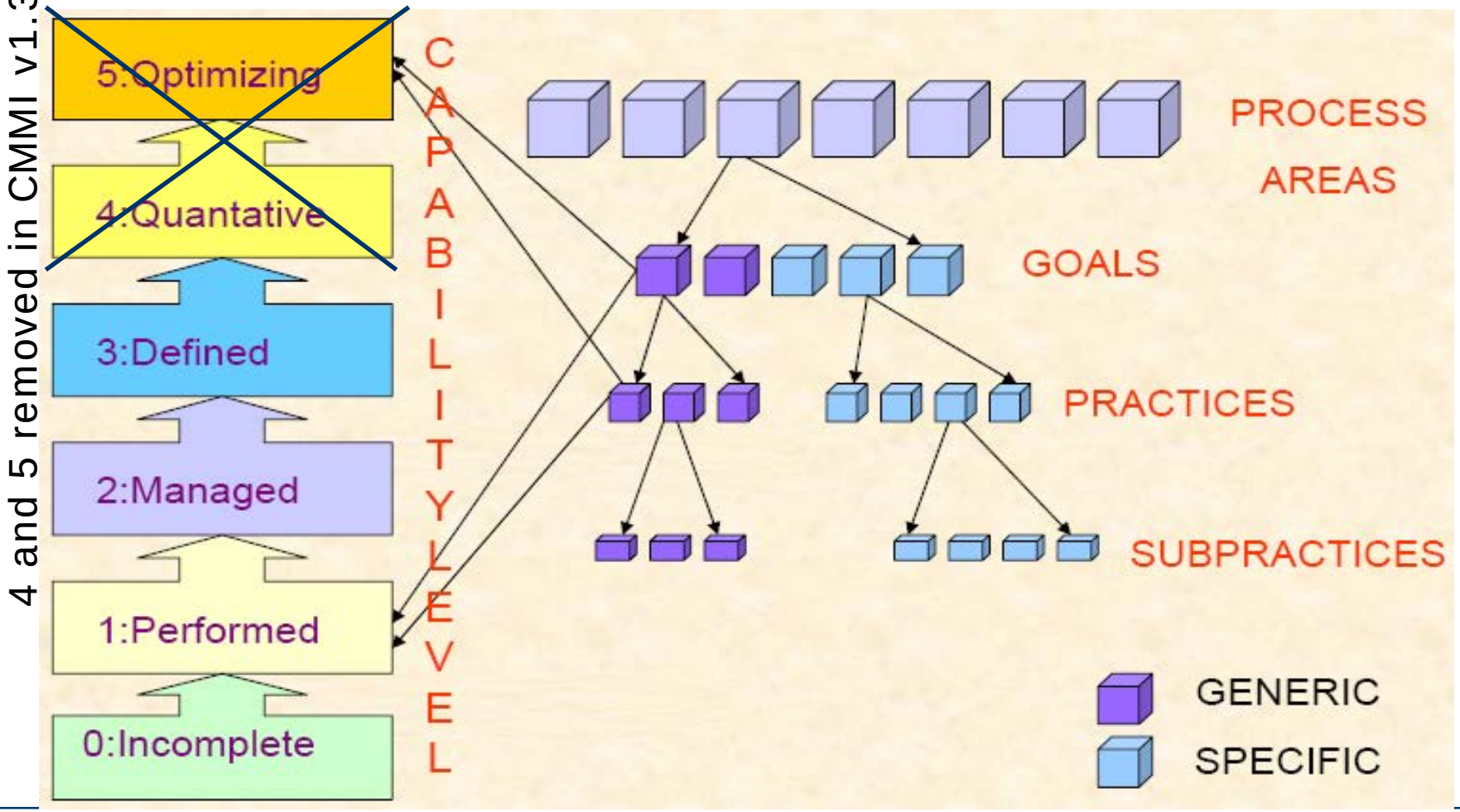
Staged representation

- Staged: Each *maturity level* comprises a set of process areas (whose goals must be fully reached)



Continuous representation

- Continuous: The pursuit of each goal (SG or GG) and practice has its own current *capability level*



Continuous representation (2)

- Contains the same process areas and practices as staged representation
- But offers the flexibility to pursue goals in different order or intensity than prescribed by the maturity levels
  - e.g. start quantitative mgmt in one area long before Level 3 is fully adressed
- Correspondingly, the handling of generic practices is different.

- We do not discuss this any further.

Introducing CMMI

- Thousands of companies by now have attempted CMM/CMMI-based software process improvement (SPI)

- Typical findings:
  - SPI is an expensive undertaking
  - It takes a long time (several years)
  - If it is successful, it results in improvements in many respects, e.g.
    - schedule adherence,
    - productivity,
    - SW quality,
    - customer satisfaction,
    - staff stress levels, etc.
  - It is difficult to do *fully* for smaller organisations
    - continuous representation often preferable

CMMI implementation status

- Relative numbers of organizations that are on level X
  - …when they take a CMMI assessment; as of 2013-09
  - http://cmmiinstitute.com/

Country	Appraisals	Maturity Level				
		1	2	3	4	5
Germany	87	12	34	41	0	0
India	755	1	35	552	5	162
United Kingdom	89	3	35	43	1	7
United States	1665	21	643	911	9	81
China	2703	2	85	2458	80	78

Effects from CMMI introduction

Summary of reports from conference presentations etc.

- was at http://www.sei.cmu.edu/cmmi/results.html (2005)
  - now moved to http://cmmiinstitute.com/ , somewhere…

Size of improvements:

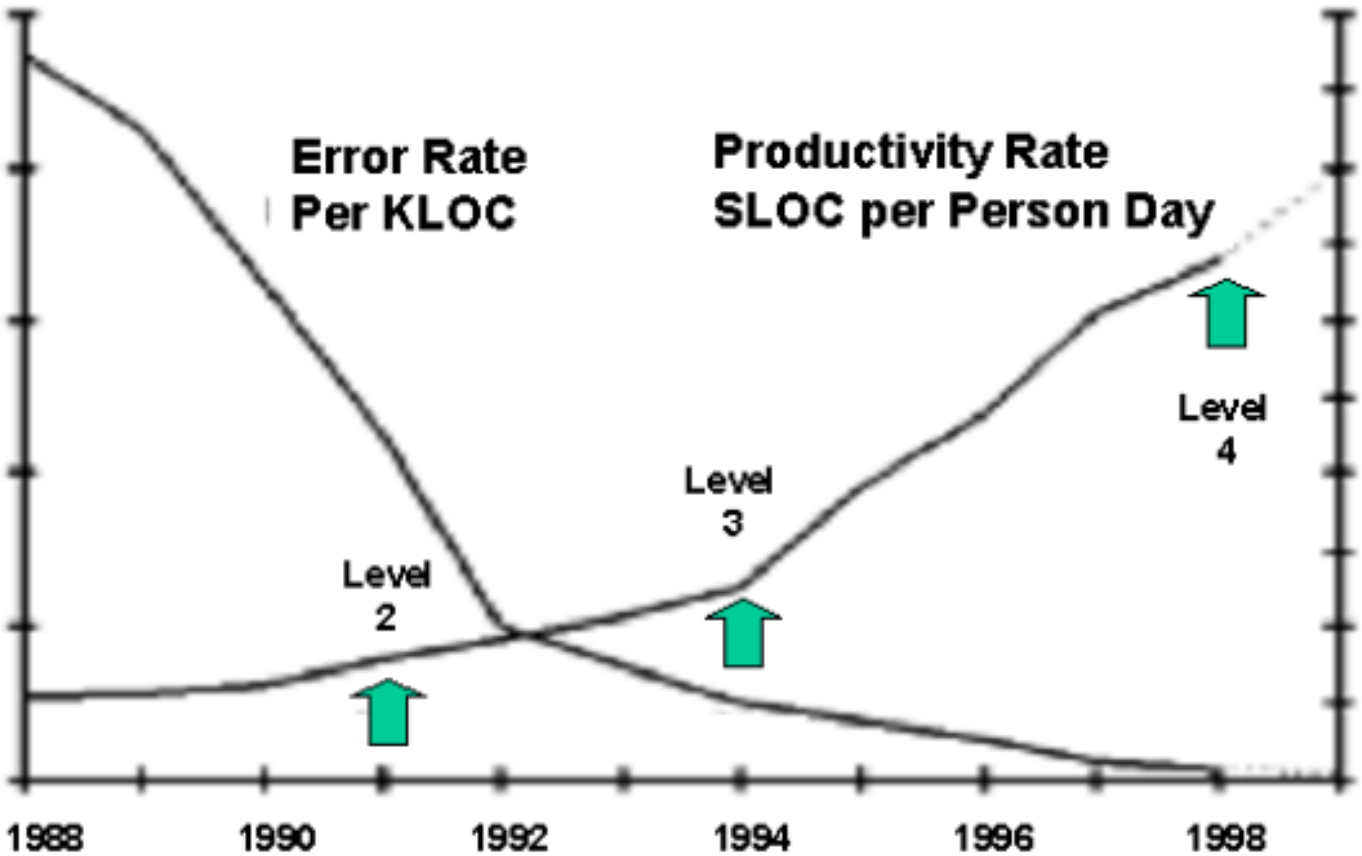
Performance Category	Median	Number of Data Points	Low	High
Cost	20%	21	3%	87%
Schedule	37%	19	2%	90%
Productivity	62%	17	9%	255%
Quality	50%	20	7%	132%
Customer Satisfaction	14%	6	-4%	55%
Return on Investment	4.7 : 1	16	2 : 1	27.7 : 1

CMMI effects: Productivity and quality

Productivity Rate and Quality Performance

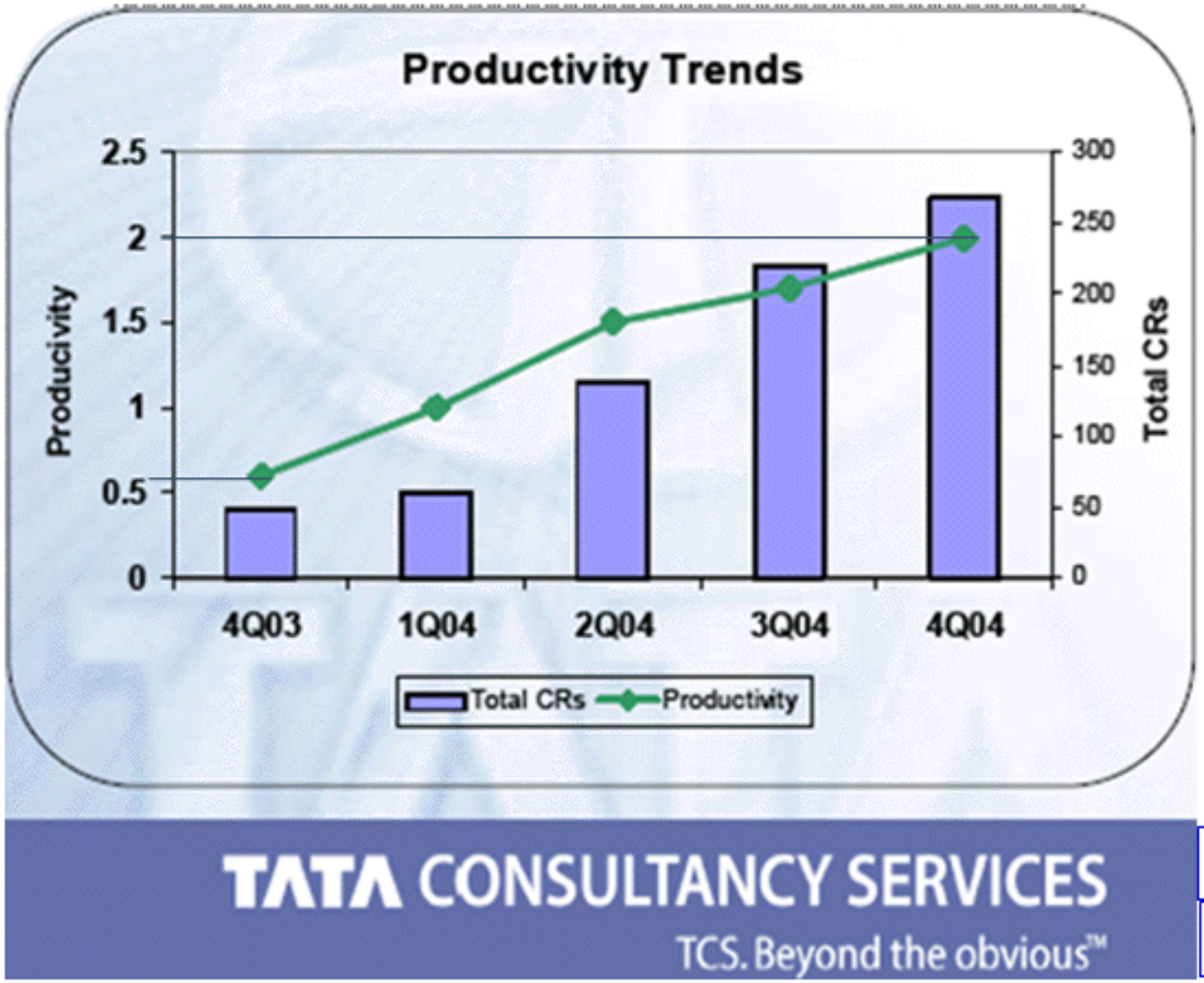
* For Software Programs

source?



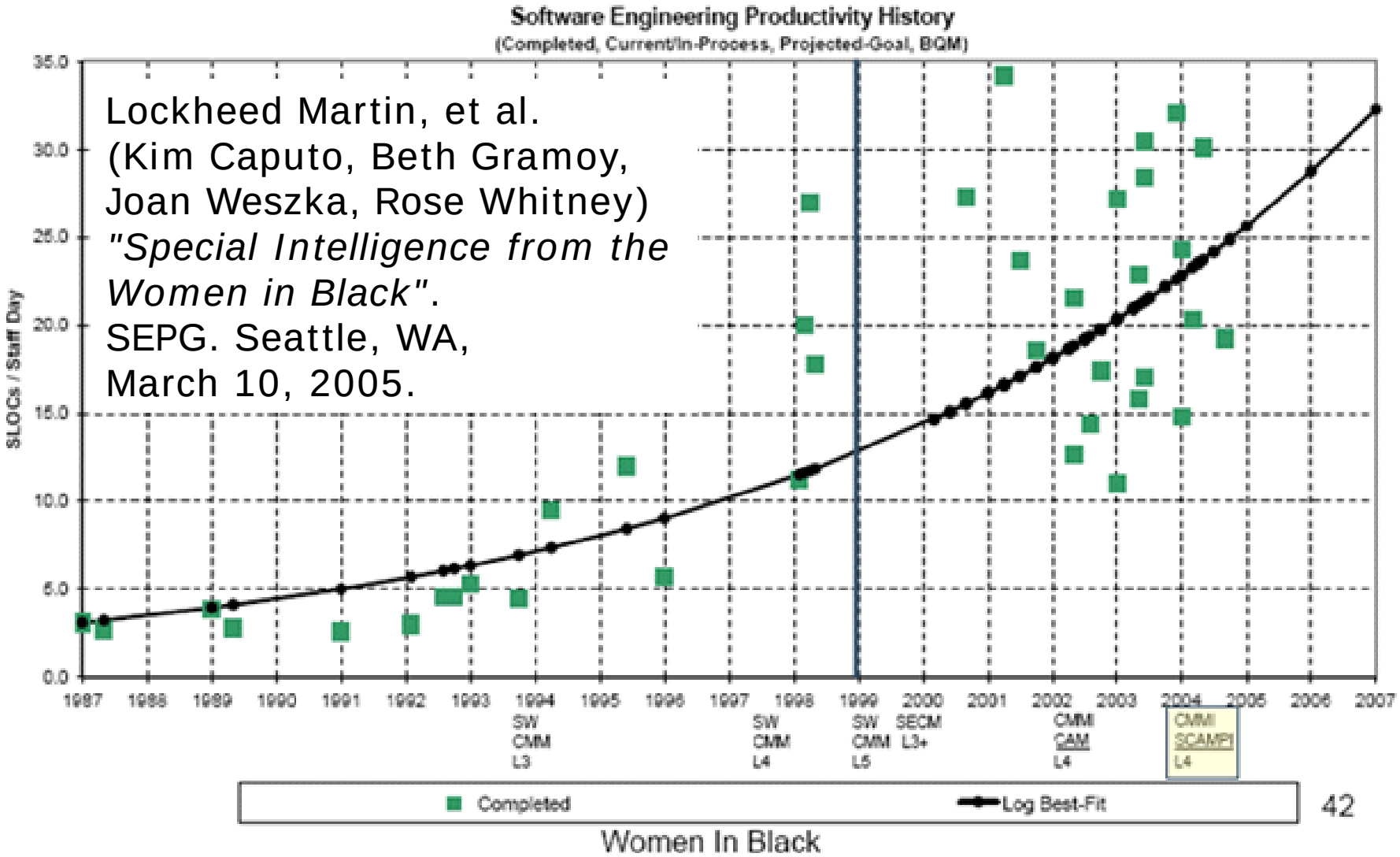
Productivity Increased By 80% As Error Rates Decreased

CMMI effects: Productivity during Level 5



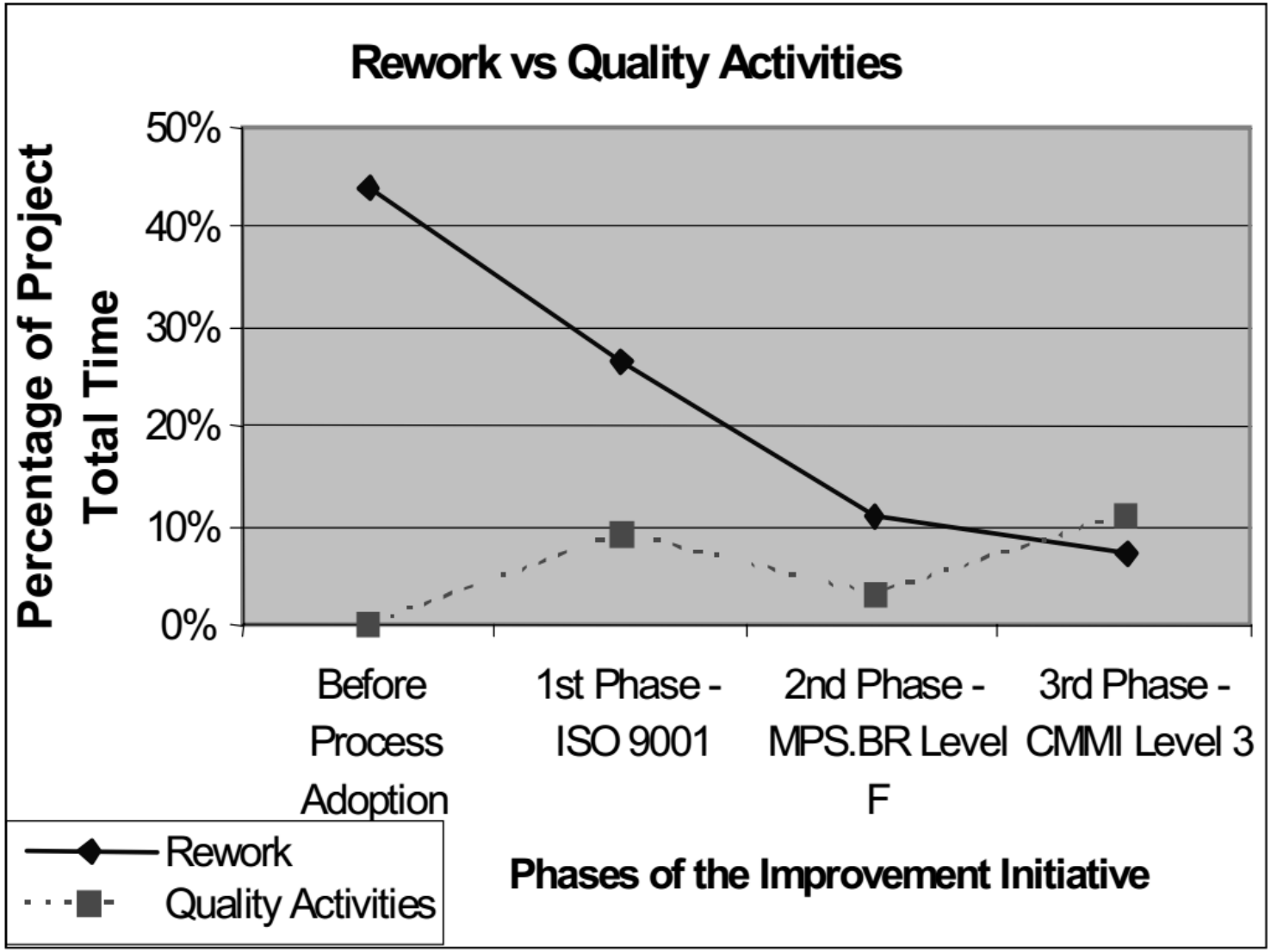
- Radice, Ron; Chawla, Alks; & Sokhi, Radbika. *"Return on Investment (ROI) from OID and CWI."* SEPG. Seattle, WA, March 8, 2005.
- CWI: Continuous workforce innovation (P-CMM Level 5)

CMMI effects: Source-code productivity improvement



Lockheed Martin, et al.
(Kim Caputo, Beth Gramoy, Joan Weszka, Rose Whitney)
"Special Intelligence from the Women in Black".
SEPG. Seattle, WA, March 10, 2005.

CMMI effects: Productivity source: Less rework

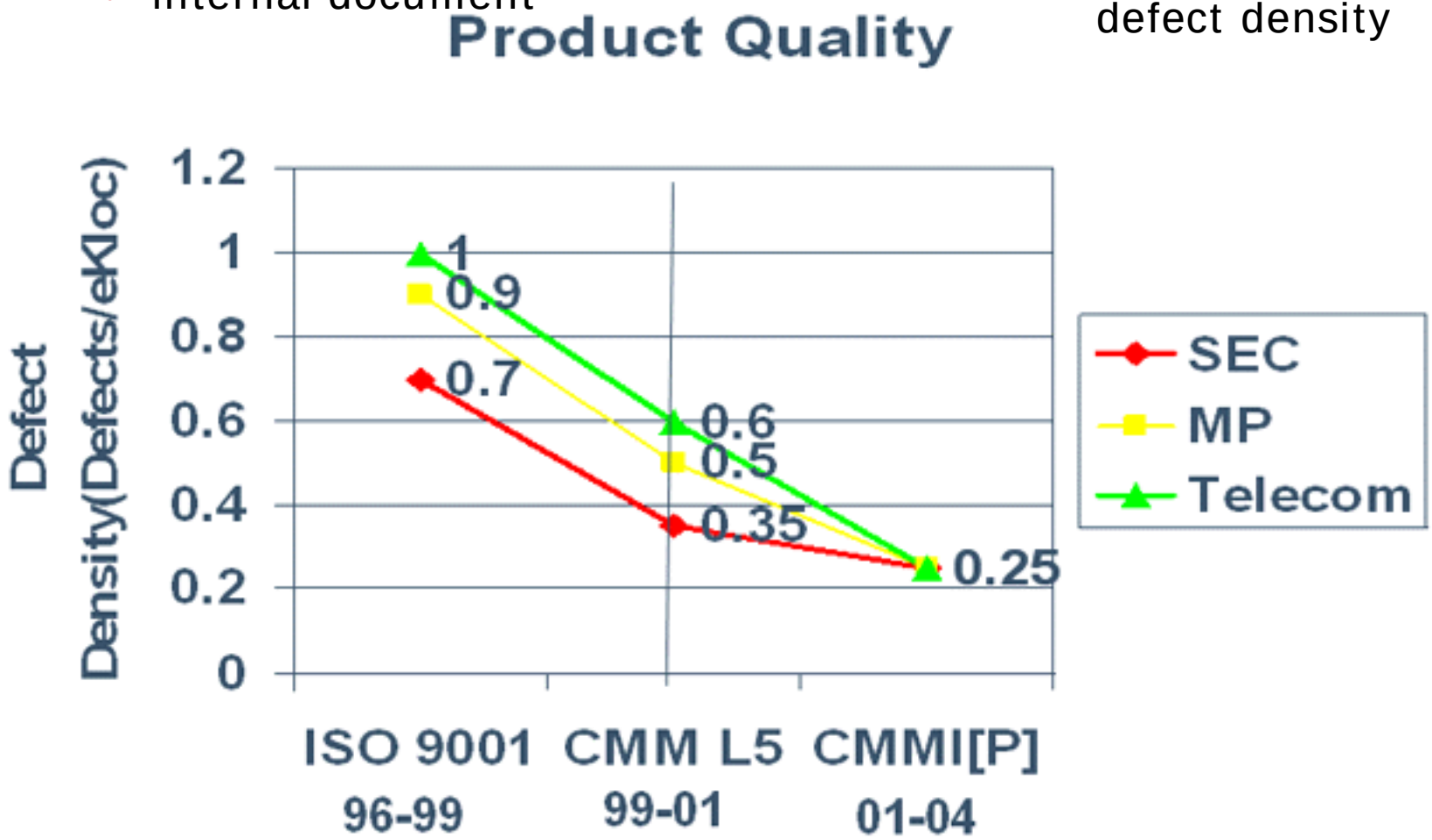


Ferreira et al.: "Applying ISO 9001:2000, MPS.BR and CMMI to Achieve Software Process Maturity: BL Informatica's Pathway", ICSE 2007

CMMI effects: Quality improvements

- Siemens Information Systems Ltd.
  - internal document

71% reduction in defect density



CMMI effects: Quality improvements

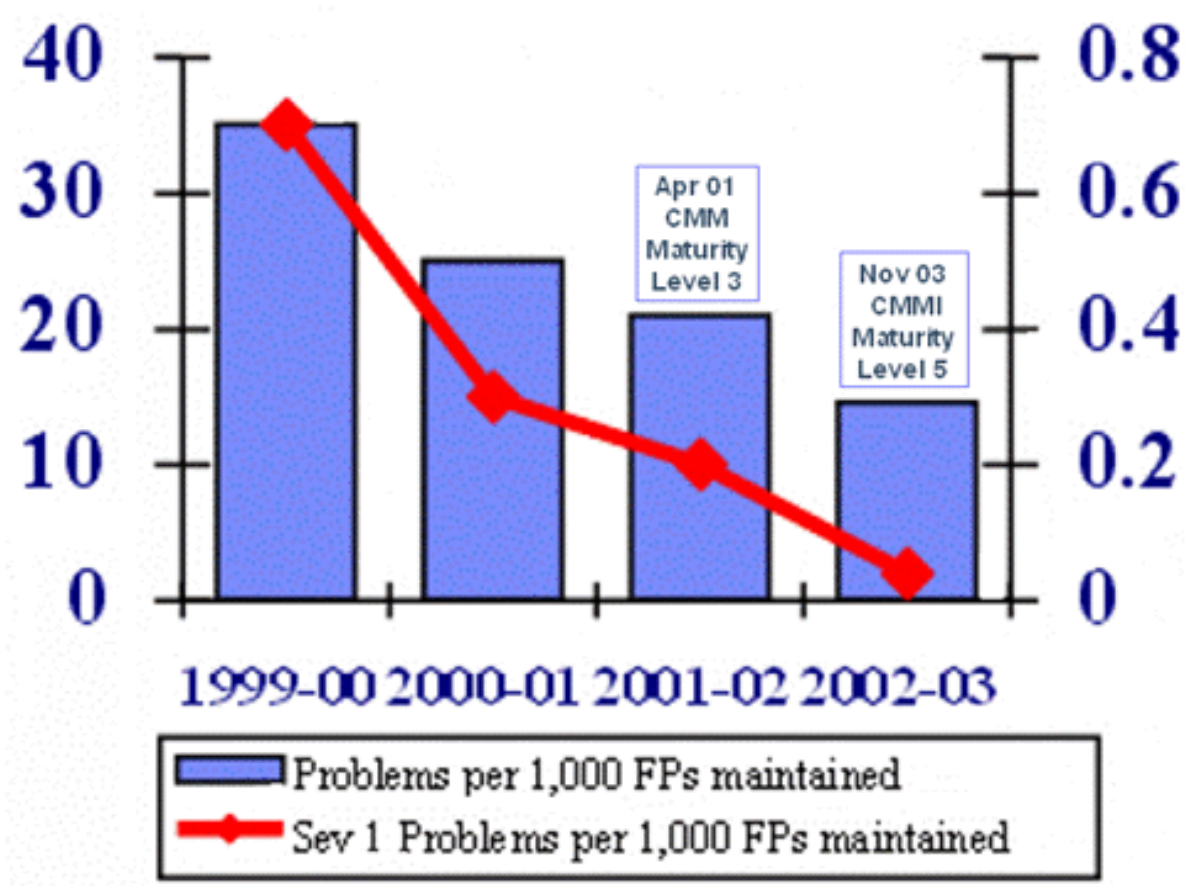


Figure 10: Problems per 1,000 FPs Maintained and Severity 1 Problems per 1,000 FPs Maintained

Maturity Level notation added by SEI

IBM Australia. "Practical Process Improvement: the Journey and Benefits." Connaughton, Colin. Australian SEPG. Adelaide, September 27-29, 2004.

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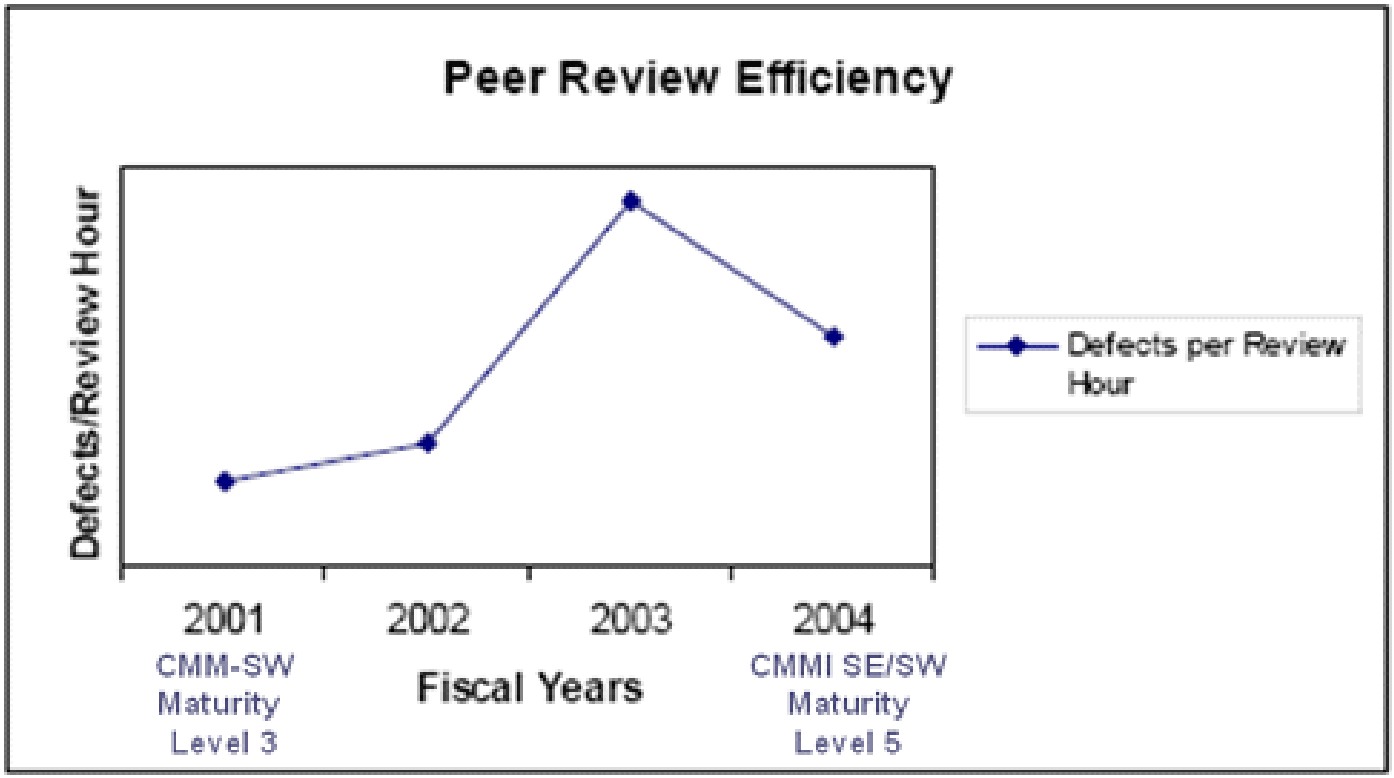
SAIC
An Employee-Owned Company

Some Trends Experienced Along the Way

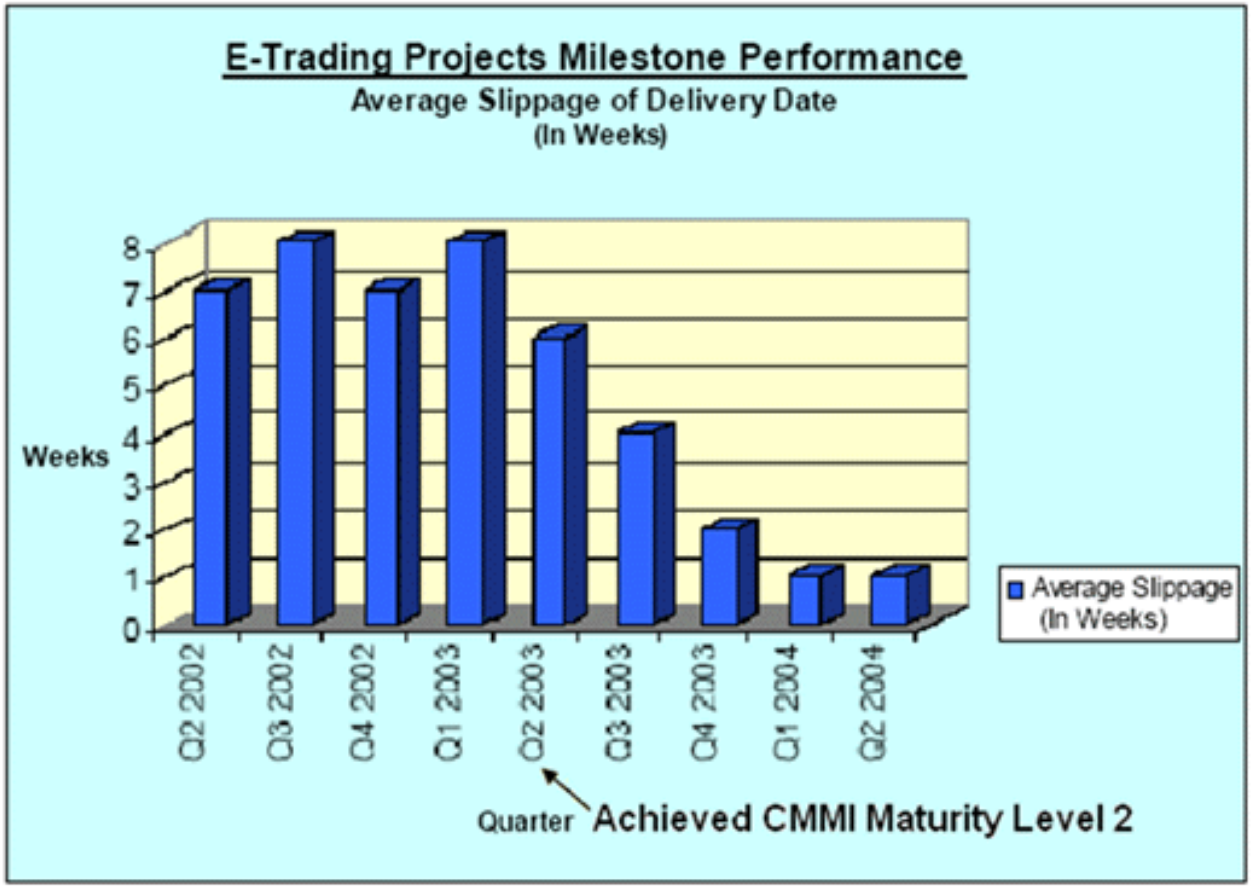


Increase in peer review efficiency despite the fact that there are fewer defects to find.

System and Network Solutions Group (SNSG)

CMMI effects: Adherence to schedule

The E-Trading team at J.P. Morgan Chase was delivering products with an average slippage of 6-8 weeks. When they achieved CMMI Level 2, the average slippage dropped to one week.



Edited by the SEI

JP Morgan Chase. "IB Technology Examples of CMMI Benefits." Tower, James. CMMI Technology Conference and User Group. Denver, CO, November 17, 2004.

CMMI implementation steps

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1 Obtain management sponsorship

- Top management support, budget
- Is a *Conditio sine qua non* (crucial requirement)

2 Understand the CMMI

- Its suggestions, the ideas behind them
- Select appropriate model(s) and representation

3 Obtain support of your organization

- Develop/communicate business goals, rationale, costs, benefits, opportunities

4 Treat process improvement as a project

- Form an engineering process group
- Understand the status quo (current processes, deficiencies)
- Sketch the target situation
- Track progress, communicate openly

CMMI in small organizations

Why?

- Growing organizations are usually process-challenged
- Partner organizations may require some CMMI compliance

Comparison to larger organizations:

- Appraisal: relatively more expensive for a small organization
  - use simpler replacements (but <u>not</u> just self-assessment)
- Process definition & support: relatively even more expensive
  - prefer the continuous representation; focus on fewer areas
  - be pragmatic and inventive; learn slowly but steadily
- Deployment: may be simpler for smaller organizations!
  - people tend to be more flexible and open

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

http://www.sei.cmu.edu/cmmi/adoption/pdf/garcia-thoughts.pdf

The Cargo Cult

Avoid the cargo cult!

- Many people consider CMMI-based process improvement a bureaucratic monster
- That is because many organizations tend to mistake some means for the end
  - They think that documentation, rules, and supervising rules <u>are</u> process improvement
  - somewhat like some Melanesian island inhabitants believe that mimicing airports can bring back the prosperity they enjoyed during World War II
- Steve McConnell: "*Cargo Cult Software Engineering*", IEEE Software, March 2000

DOs and DON'Ts

Senior Management:

- Don't Treat the Level as the Goal
  - business objectives first
- **Do Pick <u>One</u>: Better, Faster, Cheaper**
  - **be realistic, even modest**
- Do Take Your Time
- Do Align the Reward System
  - reward for improvement, not only for the bottom line
- Do Lead by Example
  - Do <u>you</u> define your processes? And follow and improve them?

CMMI:

- Don't Treat CMMI as the Bible
  - lots of room for improvement
  - other good sources exist
- Don't CMMI-train the Masses
  - this just produces opposition and/or confusion
- **Become a Stronger Level 1**
  - **incremental improvements are useful**
  - **focus on strongest pain first**
- Do Use Both the Continuous and the Staged Representation
  - continuous-only may overlook important areas
  - staged-only may be too painful and slow

http://www.sei.cmu.edu/cmmi/presentations/sepg04.presentations/dos-donts.pdf

DOs and DON'Ts (2)

Measurement:

- Do Employ Basic Measures Now!
  - to obtain a baseline
  - schedule, effort, defects
- Don't Collect Data You Don't Use
  - don't create write-only DBs
  - **don't make surveys you won't act upon**
  - think in terms of return-on-investment (ROI)
- Do Enhance Data Integrity
  - invalid or undefined data is worse than no data
  - automate data collection

Process:

- Don't Over-Engineer Processes
  - Remember Parkinson's Law
  - Rather involve many people a little (feedback/improvements)
  - Process definitions are not training materials
    - They should be rather terse
- Do Standardize Process, Not Procedure
  - What, not how
- **Do Target "Good Practice", Not "Best Practice"**
  - **avoid religious wars**
  - weigh consistency against cost

DOs and DON'Ts (3)

Behavioral change:

- Do Eliminate Low-Value-Added Tasks
  - This will also make you friends
- **Do Pilot Early and Often**
  - Theoretical considerations are often incomplete or wrong
- Do Become a Learning Organization
  - Reflect frequently on risks, things that work/don't work
- Don’t Ignore the Adoption Curve
  - target *early adopters* first
  - capture the *early majority* then
  - apply pressure to the *late majority* only then
  - eventually punish *laggards*

DOs and DON'Ts: Avoid documentation glut

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How to avoid writing too much process documentation:

- Process definition **must be driven by a need**
  - Do not write more than necessary to satisfy the need
  - Write only as much as users will want to read
- Finish version 1 of each document on the day you start it
- **Focus on quality**, not quantity
  - Start with a very concise description
  - Refine the contents also by removal, not just by addition
- If a document frequently needs change, **remove detail**
- **Avoid redundancy** across documents

Other process maturity models

"Systematic Literature Review of Software Process Capability/Maturity Models" (SPICE conference, 2010) found 52 different models described in the literature

- 29 specialized for particular domains
  - e.g. application domains: knowledge management, automotive systems, e-learning.
  - e.g. specialized topics: security engineering, testing assurance.
  - e.g. particular constraints: XP, SME (small/medium enterprises).
- Most are based on one or more of the same few generic models:
  - 11 on CMMI-DEV
  - 31 on the older CMM
  - 19 on ISO/IEC 15504 SPICE (similar to CMMI continuous)
  - 9 on ISO 9000 (quality mgmt. process standard)
  - 8 on ISO/IEC 12207 (SW process lifecycle standard)

CMMI summary

- CMMI is a framework for process maturity assessment
  - not a cookbook for SW process improvement (SPI)
- It considers 7+11+2+2 key process areas
  - prescribes goals for each
  - suggests practices for each
- Grouped into 4 maturity levels:
  - 2:managed, 3:defined, 4:quantitatively managed, 5:optimizing.
- Reach goals to reach levels
- Or use the continouous representation
  - pursue goals and practices as fits best
  - 4 capability levels: 0:incomplete, 1:performed, 2:managed, 3:defined
- CMMI-based SPI:
  - takes long
  - produces improved outcomes
  - can take many shapes
    - in particular in smaller organizations (continuous representation)
  - must beware of the cargo cult

CMMI: So what?

- When talking about process, CMMI provides a general framework
- We will use it as such in this course
- For each topic/proposal, we will ask:
  - What CMMI process areas are addressed?
  - How comprehensive is this proposal?
  - Can it be combined with others?

Thank you!