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COLLEGE OF ENGINEERING
AND COMPUTER SCIENCE

Advanced Software Process

CMMI

Capability Maturity Model Integration

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Objectives

This document has been prepared mainly for the students in my Software Engineering class:

- Who want to learn CMM/CMMI

- Who want to understand and improve their capability to develop software effectively

- Who want to understand the key practices that are part of effective processes for developing or maintaining software, and to identify the key practices that are needed to achieve the next maturity level in the CMMI

- Who want to identify the risks of having a particular organization perform the work of a contract

Introduction

- CMM
- CMMI

What is CMM?

- A model is a simplified representation of the world.

- Capability Maturity Model (CMM)
  - Sponsored by the US DoD and many other associations
  - To determine an organization's current state of process maturity, the SEI uses an assessment that results in a five point grading scheme.
  - The grading scheme determines compliance with a Capability Maturity Model (CMM) that defines key activities required at different levels or process maturity.

What is CMM?

- CMMs contain the essential elements of effective processes for one or more bodies of knowledge.

  – These elements are based on the concepts developed by Crosby (1979), Deming (1986), Juran (1988), and Humphrey (1989).

What is CMM?

- The CMM provides a measure of the global effectiveness of a company's software engineering practices and establishes five process maturity levels:
    - Level 1: Initial
    - Level 2: Repeatable
    - Level 3: Defined
    - Level 4: Managed
    - Level 5: Optimizing

CMM

- The Five Levels of Software Process Maturity in CMM
- [Paulk et al. 1993]
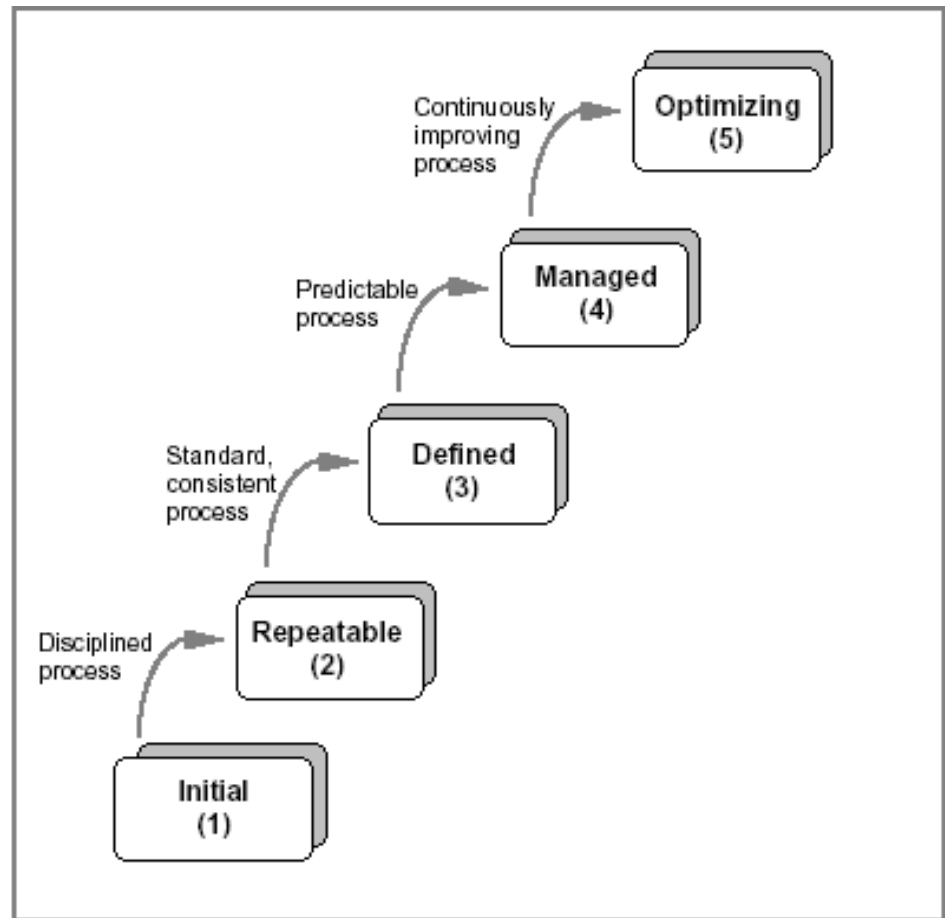
CMM

- The CMM can be used for:

    – Software process improvement

    – Software process assessment

    – Software capability evaluation

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CMM

- Software process improvement
  - An organization plans, develops, and implements changes to its software process.

- Software process assessment
  - A trained team of software professionals determine the state of an organization's current software process, determines the high-priority software process-related issues facing an organization, and obtains the organizational support for software process improvement.

CMM

- Software capability evaluation
  - A trained team of professionals identifies contractors who are qualified to perform the software work or monitors the state of the software process used on an existing software effort.

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CMM

- Structure of CMM [Paulk et al. 1993]
- The components of the CMM
  - Maturity levels
  - Process capability
  - Key process areas
  - Goals
  - Common features
  - Key practices
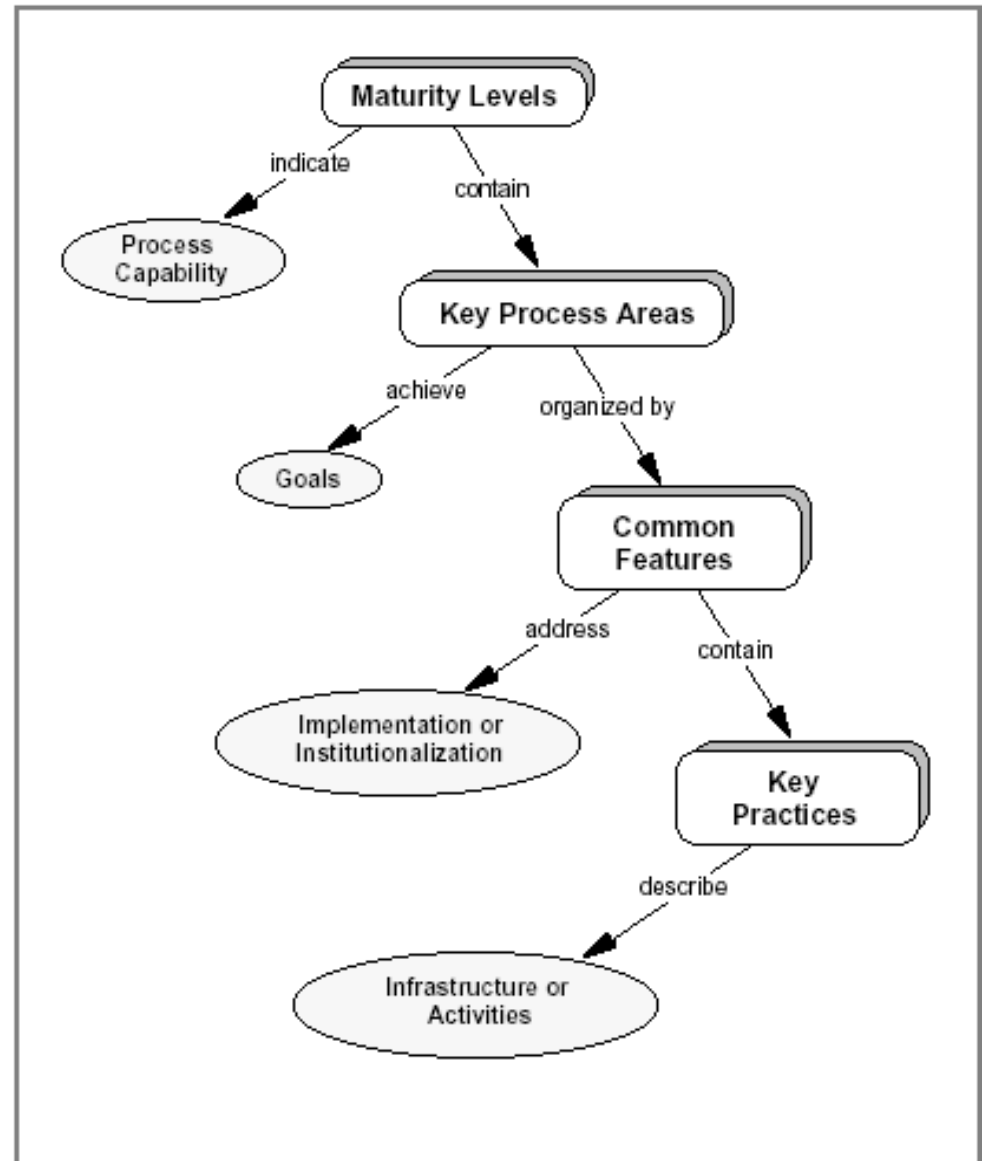
CMM

- Maturity levels
  - A maturity level is a well-defined evolutionary plateau toward achieving a mature SW process.
  - The five maturity levels provide the top-level structure of the CMM.

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CMM

- Process capability

  - Software process capability describes the range of expected results that can be achieved by following a software process.

  - The software process capability of an organization provides one means of predicting the most likely outcomes to be expected from the next software project the organization undertakes.

CMM

- The Key Process Areas by Maturity Level

  [Paulk et al. 1993]

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CMM
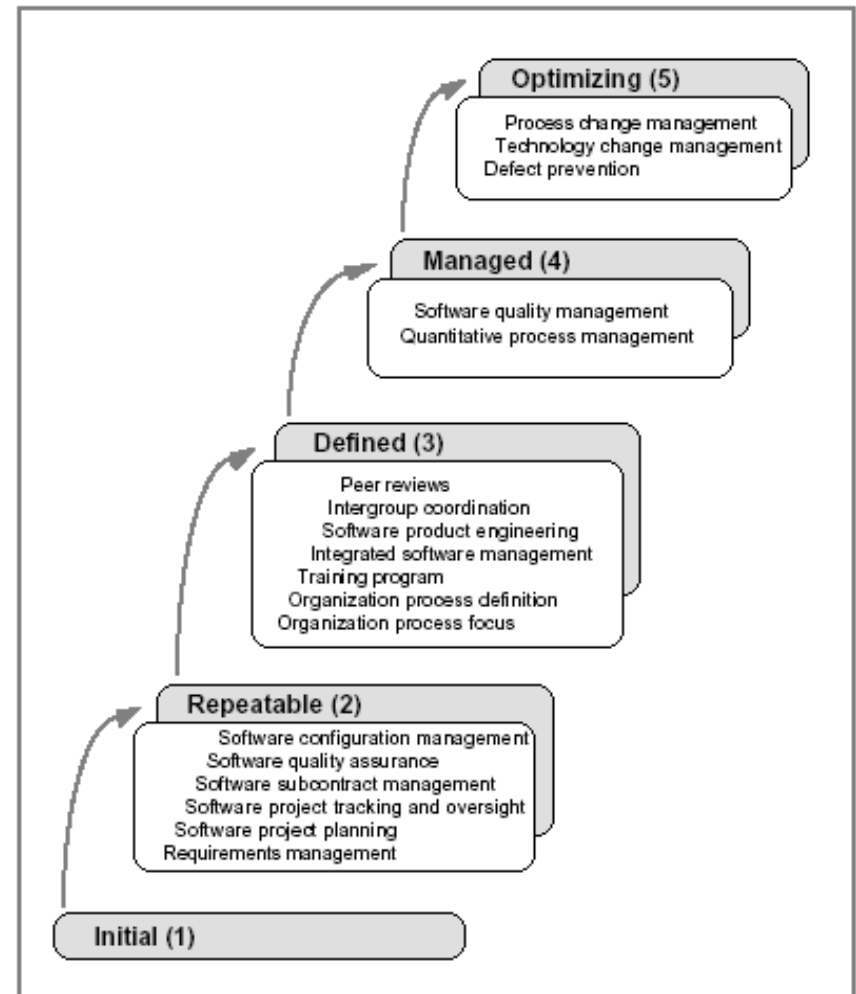
- The Key Process Areas Assigned to Process Categories [Paulk et al. 1993]

Processes Categories / Levels	Management *Software project planning, management, etc.*	Organizational *Senior management review, etc.*	Engineering *Requirements analysis, design, code, test, etc.*
5 Optimizing		Technology Change Management	
		Process Change Management	Defect Prevention
4 Managed	Quantitative Process Management		Software Quality Management
3 Defined	Integrated Software Management Intergroup Coordination	Organization Process Focus Organization Process Definition Training Program	Software Product Engineering Peer Reviews
2 Repeatable	Requirements Management Software Project Planning Software Project Tracking & Oversight Software Subcontract Management Software Quality Assurance Software Configuration Management		
1 Initial	Ad Hoc Processes		

CMM

- Conceptual SW Process Framework Used in the CMM [Paulk et al. 1993]
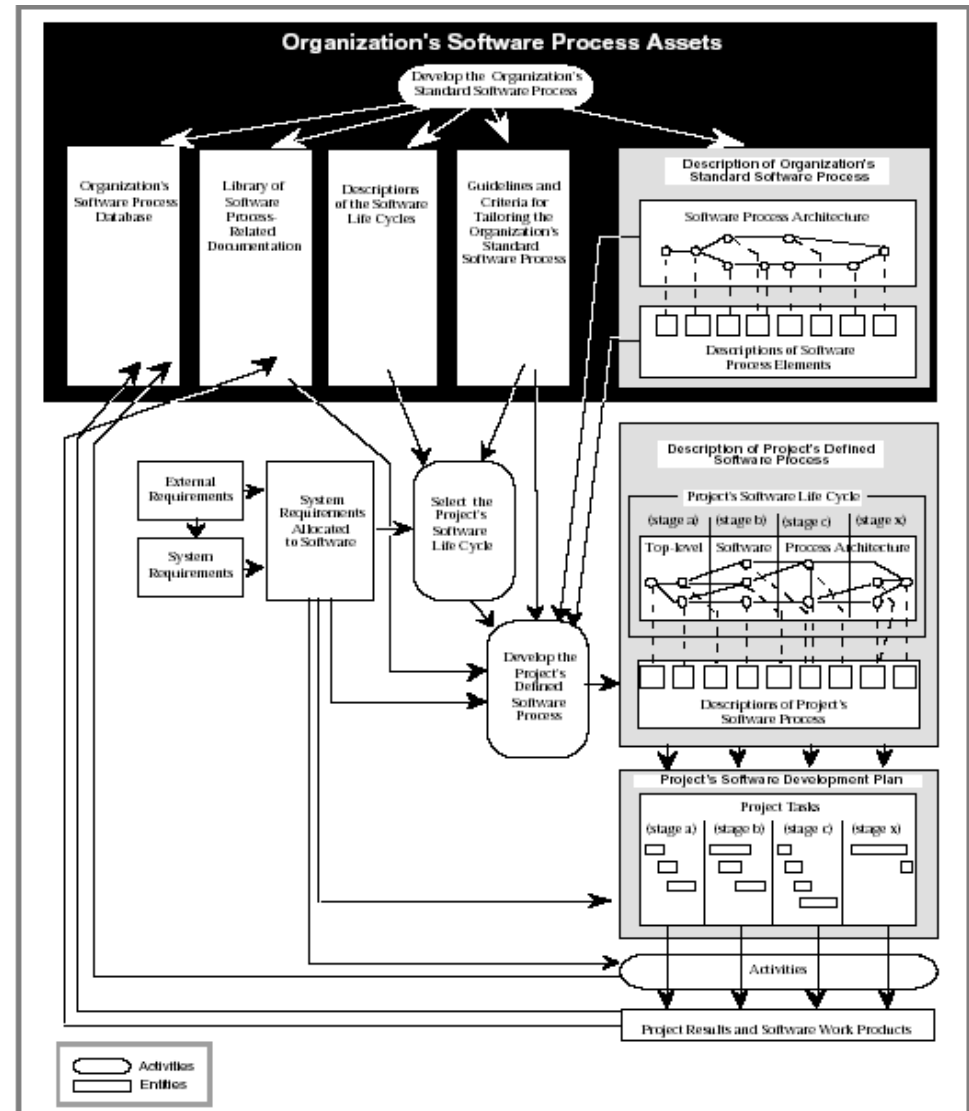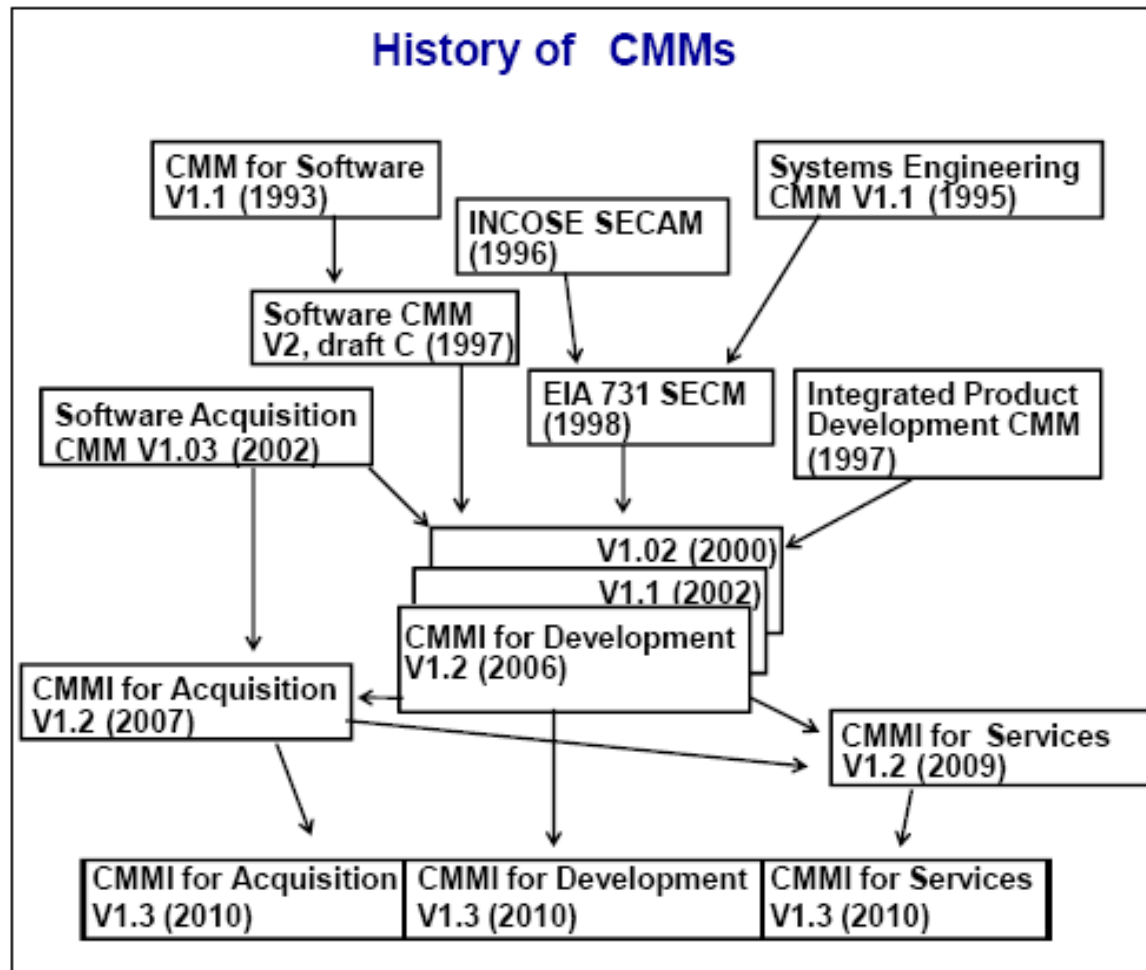
What is CMMI

- Capability Maturity Model Integration (CMMI)
- The CMM Integration project was formed to sort out the problem of using multiple CMMs.
- Organizations from industry, government, and the SEI joined together to develop the CMMI Framework, a set of integrated CMMI models, a CMMI appraisal method, and supporting products.

What is CMMI

- The CMMI Product Team's mission was to combine the following three source models into a single improvement framework for use by organizations pursing enterprise-wise process improvement:
    - Capability Maturity Model for Software (SW-CMM) v2.0 draft C
    - Electronic Industries Alliance Interim Standard (EIA/IS) 731 (SE-CM) – The Systems Eng CM
    - Integrated Product Development Capability Maturity Model (IPD-CMM) v0.98

What is 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)
- Software Acquisition CMM V1.03 (2002)
- 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 (2009)
- CMMI for Acquisition V1.3 (2010)
- CMMI for Development V1.3 (2010)
- CMMI for Services V1.3 (2010)

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What is CMMI

- Using processes that promote consensus, the CMMI Product Team has built a framework that accommodates multiple disciplines and is flexible enough to support two different representations:
  - Staged
  - Continuous

CMMI

- CMMI models provide guidance to use when developing processes.

- CMMI models are not processes or process descriptions.
  - The actual processes used in an organization depend on many factors, including application domain(s) and organization structure and size.
  - In particular, the process areas of a CMMI model typically do <u>not</u> map one to one with the processes used in your organization.

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Purpose of CMMI

- A process is a leverage point for an organization's sustained improvement.

- The purpose of CMM Integration is to provide guidance for improving your organization's processes and your ability to manage the development, acquisition, and maintenance of products or services.

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Purpose of CMMI

- CMMI places proven approaches into a structure that helps your organization appraise its organizational maturity or process area capability, establish priorities for improvement, and implement these improvements.

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CMMI v1.3 Architecture

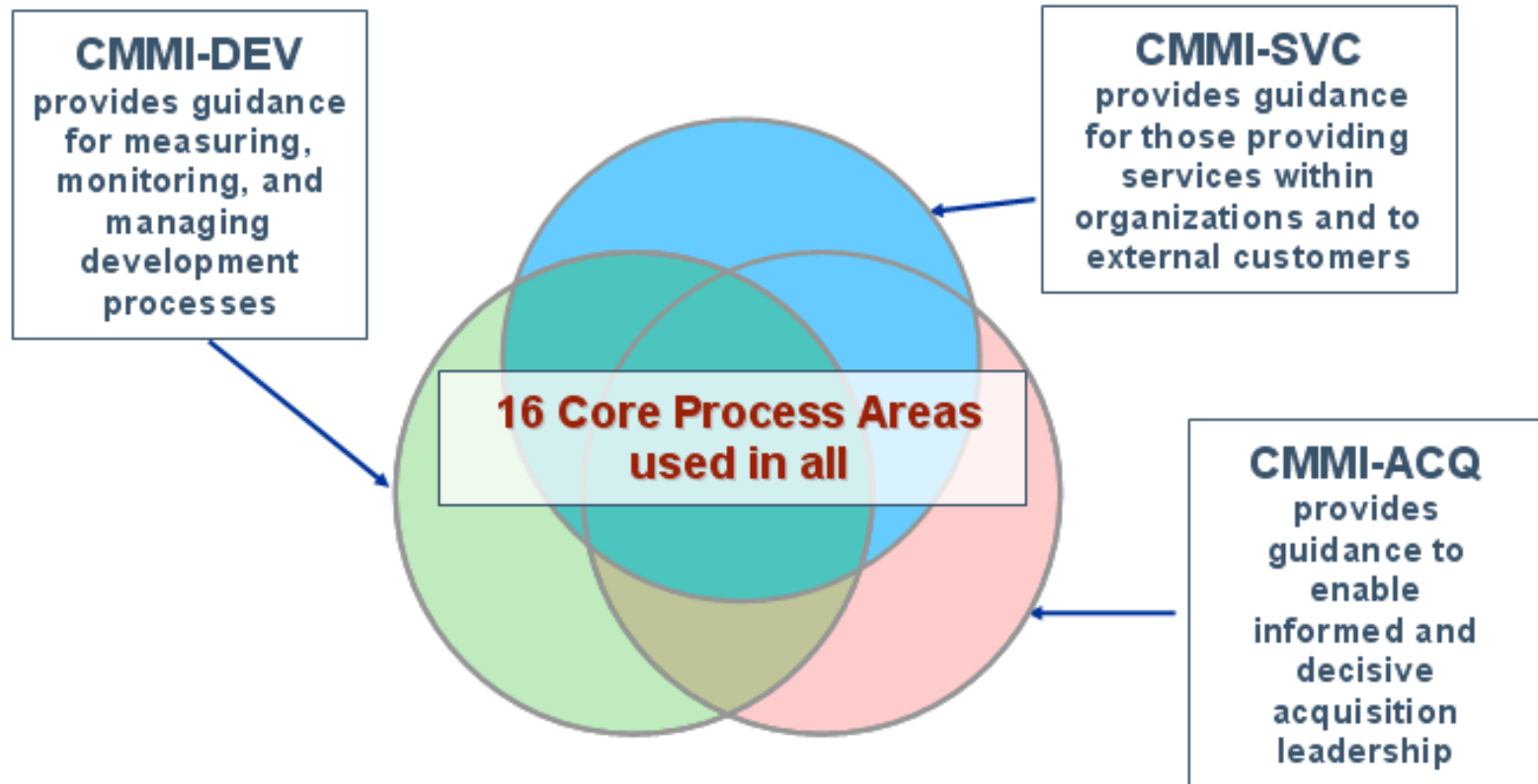- CMMI Framework

CMMI Framework

- The CMMI Framework addresses the following materials:
  - Model
  - Appraisal
  - Training
- The model portion of the CMMI Framework is composed of the following:
  - CMMI Model Foundation
  - Shared material
  - Constellation-specific material
    - Acquisition
    - Development
    - Services

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CMMI Constellations

- CMMI for Development (CMMI-DEV)

- CMMI for Services (CMMI-SVC)

- CMMI for Acquisition (CMM-ACQ)

CMMI
Three Complementary Constellations

CMMI-DEV provides guidance for measuring, monitoring, and managing development processes

CMMI-SVC provides guidance for those providing services within organizations and to external customers

16 Core Process Areas used in all

CMMI-ACQ provides guidance to enable informed and decisive acquisition leadership

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CMMI for Services

- Some service organizations apply CMMI to their work, although this requires significant interpretation by both the organizations and their appraisers.

- The CMMI for Services model will improve consistency and payoff for service organizations because it will include service deployment practices that are not covered by the current CMMI model.

CMMI for Services

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- The CMMI for Services model will improve consistency and payoff for service organizations because it will include service deployment practices that are not covered by the current CMMI model.

CMMI for Services
Purpose and Sponsors

- The purpose of "CMMI for Services" is to extend the CMMI framework to cover the provision of services.

- The "CMMI for Services" project is sponsored by the following organizations:

  - CMMI Steering Group

  - Office of the Secretary of Defense for Acquisition, Technology, and Logistics

  - National Defense Industrial Association, Systems Engineering Division

  - Software Engineering Institute

  - Northrop Grumman

CMMI for Services
What is a Service?

- Products may be delivered in a variety of forms, including artifacts (e.g., hardware, software, or user documentation), services (e.g., training, maintenance, or operational support), and combinations of these.

- A service is a product that is intangible and non-storable.

CMMI for Services
What is a Service?

- For the "CMMI for Services" model, Northrop-Grumman is leading an integrated team consisting of participants from the following organizations:
  - Software Engineering Institute
  - Boeing
  - Det Norske Veritas
  - Lockheed Martin
  - Raytheon
  - Science Applications International Corporation
  - SRA International
  - Systems and Software Consortium

CMMI for Acquisition

- Some acquisition organizations apply CMMI to their work, although the Engineering process areas require significant interpretation.

- A "CMMI for Acquisition" model will improve consistency and payoff for acquisition organizations because it will include acquisition practices that are useful, but not covered in the CMMI for Development models.

- This model will build upon the initial work published by General Motors Corporation.

CMMI for Acquisition Purposes and Sponsors

- The purpose of "CMMI for Acquisition" is to extend the CMMI framework to cover the acquisition of products and services.
- The "CMMI for Acquisition" project is sponsored by the following organizations:
  - CMMI Steering Group
  - Office of the Secretary of Defense for Acquisition, Technology, and Logistics
  - National Defense Industrial Association, Systems Engineering Division
  - General Motors
  - Software Engineering Institute
  - NASA
  - Department of Homeland Security

CMMI for Acquisition
What is Acquisition?

- Acquisition, as defined in the CMMI models, is the process of obtaining products (goods and services) through contract.

- Some call these processes "procurement" or "outsourcing."

CMMI for Acquisition Team

- The SEI is leading an integrated team consisting of multiple organizations to develop the "CMMI for Acquisition (CMMI-ACQ)" constellation.

Selecting a CMMI Model

- Representation
- Body of Knowledge

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Selecting a CMMI Model

- There are multiple CMMI models available, as generated from the CMMI Framework.

- Consequently, you need to be prepared to decide which CMMI model best fits your organization's process-improvement needs.

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Selecting a CMMI Model

- You must select a representation, either continuous or staged.

- You must determine the bodies of knowledge you want to include in the model your organization will use.

  - System Engineering
  - Software Engineering
  - Integrated Product and Process Development
  - Supplier Sourcing

Representations: Continuous or Staged?

- The CMMI represents a process meta-model in two different ways:
  - (1) as a continuous model and
  - (2) as a staged model.
- A representation reflects the organization, use, and presentation of components in a model.
  - There are many valid reasons to select one representation or the other.

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Continuous Representation

- If you choose the continuous representation, expect that the model will do:
  - Allow you to select the order of improvement that best meets the organization's objectives
  - Enable comparisons across and among organizations on a process area by process area basis or by comparing results through the use of equivalent staging
    - Provide an easy migration from EIA/IS 731 to CMMI
    - Afford an easy comparison of process improvement to ISO/IEC 15504

Staged Representation

- If you choose the staged representation, expect that the model will do:
  - Provide a proven sequence of improvements, beginning with basic management practices and progressing through a predefined and proven path of successive levels, each serving as a foundation for the next
  - Permit comparisons across and among organizations by the use of maturity levels
    - Provide an easy migration from the SE-CMM to CMMI
    - Provide a single rating that summarizes appraisal results and allows comparisons among organizations

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Which Integration Model to Choose?

- Currently there are four bodies of knowledge available to you when selecting a CMMI model:
  - System Engineering
  - Software Engineering
  - Integrated Product and Process Development (IPPD)
  - Supplier Sourcing

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Systems Engineering

- Systems engineering covers the development of total systems, which may or may not include software.

- Systems engineers focus on transforming customer needs, expectations, and constraints into product solutions and supporting these product solutions throughout the life of the product.

Software Engineering

- Software engineering covers the development of software systems.

- Software engineers focus on applying systematic, disciplined, and quantifiable approaches to the development, operation, and maintenance of software.

Integrated Product and Process Development

- IPPD is a systematic approach that achieves a timely collaboration of relevant stakeholders throughout the life of the product to better satisfy customer needs, expectations, and requirements.

- The processes to support an IPPD approach are integrated with the other processes in the organization.

  - In Version 1.3, the IPPD material has been removed and some specific practices were added to address teams.

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CMMI and Six Sigma

- Six Sigma is an approach to business improvement that includes improvement framework, performance measurement and a toolkit.
  - Six Sigma originated in the manufacturing industry, but it has been applied to many areas as well.
- In some cases, organizations simultaneously adopt Six Sigma and CMMI.
  - It has been demonstrated that the rate of recognizing CMMI maturity is clearly enhanced by the adoption of Six Sigma.

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Your Approach to Process Improvement

- How to use CMMI depends on your situation.

Process Area Components

- Required Components

- Expected Components

- Informative Components

Model Components

- Model components are grouped into three categories:
    - Required components
    - Expected components
    - Informative components

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Required Components

- Required components describe what an organization must achieve to satisfy a process area.

  – Specific goals

  – Generic goals

- This achievement must be visibly implemented in an organization's processes.

  – Goal satisfaction is used in appraisals as the basis for deciding whether a process area has been achieved and satisfied.

Expected Components

- Expected components describe what an organization may implement to achieve a required component.

- Expected components guide those who implement improvements or perform appraisals.

- Expected components include the
  - Specific practices
  - Generic practices

Informative Components

- Informative components provide details that help organizations get started in thinking about how to approach the required and expected components.

- Informative model components

  - Sub-practices, typical work products, amplifications (information relevant to a particular discipline), generic practice elaborations, goal and practice titles, goal and practice notes, references

CMMI Model Components

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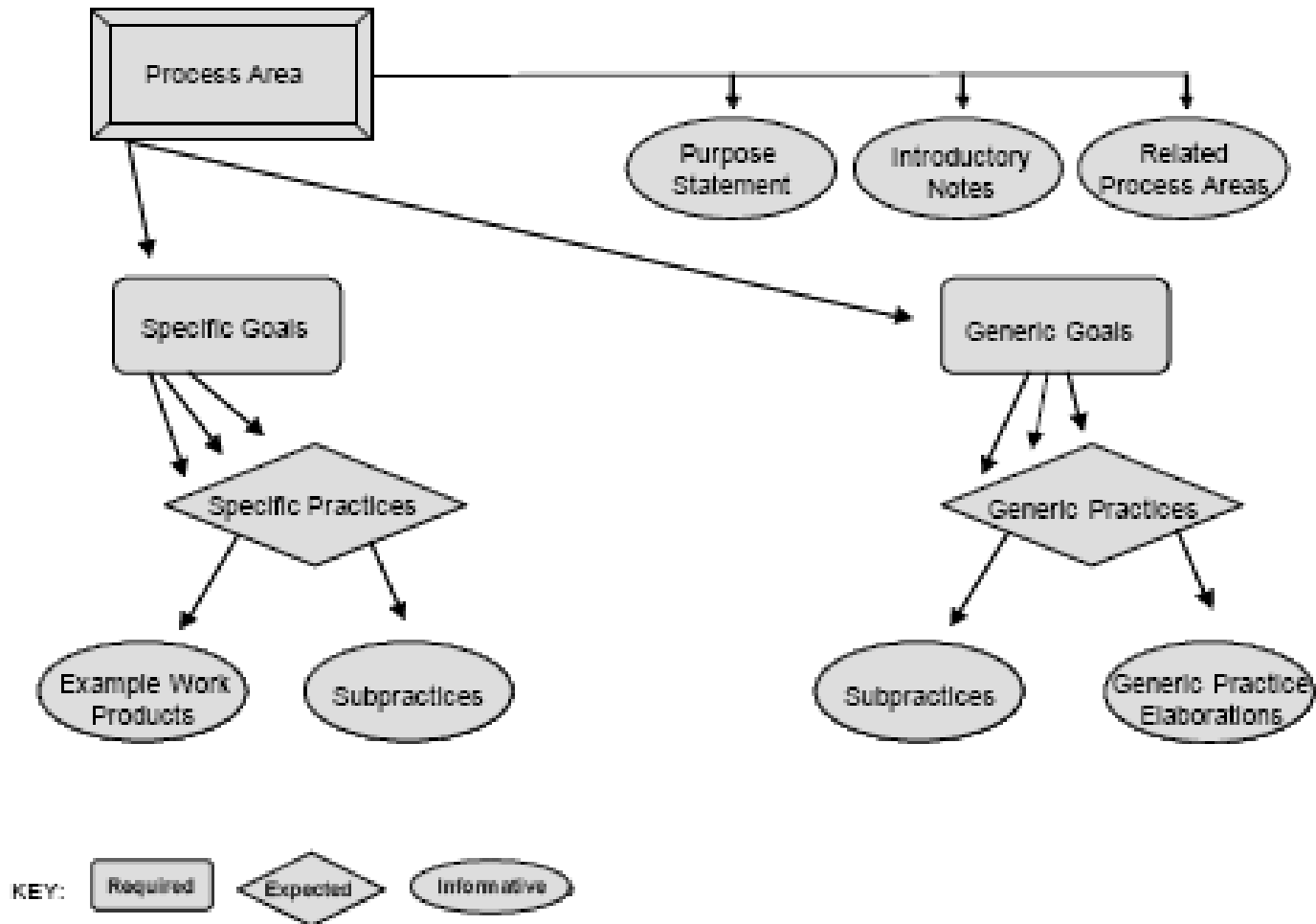
CMMI Models

- Understanding Levels

- Capability Levels

- Maturity Levels

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Levels

- Levels are used in CMMI to describe the evolutionary path recommended for an organization that wants to improve the processes it uses to develop and maintain its products and services.

- CMMI supports two improvement paths.

Levels

- The <u>first path</u> enables organizations to incrementally improve processes corresponding to an individual process area (or process areas) selected by the organization.

- The <u>second path</u> enables organizations to improve a set of related processes by incrementally addressing successive sets of process areas.

Levels

- These two improvement paths are associated with two types of levels that correspond to the two representations.

- Two representations and levels

  - Continuous representation

    - Capability level

  - Staged representation

    - Maturity level

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Levels

- Levels characterize improvement from an ill-defined state to a state that uses quantitative information to determine and manage improvements that are needed to meet an organization's business objectives.

Continuous CMMI Meta-Model

- The continuous CMMI meta-model describes a process in two dimensions: process area and capability level.

- Each process area (e.g., project planning, requirements management) is formally assessed against specific goals and practices and is rated according to the capability levels.

Capability Levels

- A capability level consists of related SPs and GPs for a process area that can improve the organization's processes associated with that process area.

- As you satisfy the SGs and GGs of a process area at a particular capability level, you reap the benefits of process improvement.

- Capability levels represent the process improvement attained in an organization.

Capability Levels

- ## Comparison of Capability and Maturity Levels

Level	Continuous Representation Capability Levels	Staged Representation Maturity Levels
Level 0	Incomplete	
Level 1	Performed	Initial
Level 2	Managed	Managed
Level 3	Defined	Defined
Level 4		Quantitatively Managed
Level 5		Optimizing

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Capability Levels

- Level 0: Incomplete

- Level 1: Performed

- Level 2: Managed

- Level 3: Defined

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Capability Levels

- Level 0: Incomplete
  - An "incomplete process" is a process that is either not performed or partially performed.
  - One or more of the specific goals of the process area are not satisfied and no generic goals exist for this level since there is no reason to institutionalize a partially performed process.

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Capability Levels

- Level 1: Performed
  - A CL 1 process is characterized as a "performed process".
  - A performed process is a process that accomplished the needed work to produce work products; the specific goals of the process area are satisfied.

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Capability Levels

- Level 2: Managed
  - A CL 2 process is characterized as a "managed process".
  - A managed process is a performed process (CL 1) that is planned and executed in accordance with policy; employs skilled people who have adequate resources to produce controlled outputs; involves relevant stakeholders; is monitored, controlled, and reviewed; and is evaluated for adherence to its process description.

Capability Levels

- Level 3: Defined
  - A CL 3 process is characterized as a "defined process".
  - A defined process is a managed process (CL 2) that is tailored from the organization's set of standard processes according to the organization's tailoring guidelines, has a maintained process description; and contributes process related experiences to the organizational process assets.

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Capability Levels

- Level 3: Defined (continued)
  - A critical distinction between capability levels 2 and 3 is the scope of standards, process descriptions, and procedures.
    - At capability level 2, the standards, process descriptions, and procedures can be quite different in each specific instance of the process (e.g., on a particular project).
    - At capability level 3, the standards, process descriptions, and procedures for a project are more consistent, except for the differences allowed by the tailoring guidelines.
    - Another critical distinction is that at capability level 3 processes are typically described more rigorously than at capability level 2.

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Capability Levels

- High maturity levels
  - The high maturity process areas focus on improving the performance of those processes already implemented. The high maturity process areas describe the use of statistical and other quantitative techniques to improve organizational and project processes to better achieve business objectives.

Capability Levels

- High maturity levels (continued)
  - After an organization has reached capability level 3 in the process areas it has selected for improvement, it can continue its improvement journey by addressing high maturity process areas:
  - OPP, QPM, CAR, OPM
  - (Organizational Process Performance, Quantitative Project Management, Causal Analysis and Resolution, and Organizational Performance Management).

Capability Levels

- High maturity levels (continued)
  - After an organization has reached capability level 3 in the process areas it has selected for improvement, it can continue its improvement journey by addressing high maturity process areas:
  - OPP, QPM, CAR, OPM
  - (Organizational Process Performance, Quantitative Project Management, Causal Analysis and Resolution, and Organizational Performance Management).

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Capability Levels

- High maturity levels (continued)
  - When continuing its improvement journey in this way, an organization can derive the most benefit by first selecting the OPP and QPM process areas, and bringing those process areas to capability levels 1, 2, and 3. In doing so, projects and organizations align the selection and analyses of processes more closely with their business objectives.

Capability Levels

- High maturity levels (continued)
  - After the organization attains CL 3 in the OPP and QPM process areas, the organization can continue its improvement path by selecting the CAR and OPM process areas.
    - In doing so, the organization analyzes the business performance using statistical and other quantitative techniques to determine performance shortfalls, and identifies and deploys process and technology improvements that contribute to meeting quality and process performance objectives. Projects and the organization use causal analysis to identify and resolve issues affecting performance and promote the dissemination of best practices.

Staged CMMI Meta-Model

- The primary difference is that the staged model defines five maturity levels (ML1 – ML5) (rather than four capability levels (CL0 – CL3)).

- A maturity level consists of related specific and generic practices for a predefined set of process areas that improve the organization's overall performance.

- To achieve a maturity level, the specific goals and practices associated with a set of process areas must be achieved.

Maturity Levels

- A maturity level is a defined evolutionary plateau for organizational process improvement.

- Each maturity level matures an important subset of the organization's processes, preparing it to move to the next maturity level.

- The maturity levels are measured by the achievement of the SGs and GGs associated with each predefined set of process areas.

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Maturity Levels

Level	Continuous Representation Capability Levels	Staged Representation Maturity Levels
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- Level 1: Initial
- Level 2: Managed
- Level 3: Defined
- Level 4: Quantitatively Managed
- Level 5: Optimizing

Maturity Levels

- Level 1: Initial
  - At ML 1, processes are usually ad hoc and chaotic.
  - The organization usually does <u>not</u> provide a stable environment to support the processes.
  - Success in these organizations depends on the competence and heroics of the people in the organization and <u>not</u> on the use of proved processes.
  - In spite of this chaos, ML 1 organizations often produce products and services that work; however, they frequently exceed their budgets and do not meet their schedules.
    - Characterized by a tendency to over-commit, abandon their processes in a time of crisis, and be an unable to repeat their successes.

Maturity Levels

- Level 2: Managed
  - At maturity level 2, the projects have ensured that processes are planned and executed in accordance with policy; the projects employ skilled people who have adequate resources to produce controlled outputs; involve relevant stakeholders; are monitored, controlled, and reviewed; and are evaluated for adherence to their process descriptions.

Maturity Levels

- Level 2: Managed (continued)
  - The process discipline reflected by maturity level 2 helps to ensure that existing practices are retained during times of stress. When these practices are in place, projects are performed and managed according to their documented plans.
  - Also at maturity level 2, the status of the work products are visible to management at defined points (e.g., at major milestones, at the completion of major tasks).
  - Commitments are established among relevant stakeholders and are revised as needed. Work products are appropriately controlled. The work products and services satisfy their specified process descriptions, standards, and procedures.

Maturity Levels

- Level 3: Defined
  - At maturity level 3, processes are well characterized and understood, and are described in standards, procedures, tools, and methods.
  - The organization's set of standard processes, which is the basis for maturity level 3, is established and improved over time.
  - These standard processes are used to establish consistency across the organization. Projects establish their defined processes by tailoring the organization's set of standard processes according to tailoring guidelines.

Maturity Levels

- Level 4: Quantitatively Managed
  - At maturity level 4, the organization and projects establish quantitative objectives for quality and process performance and use them as criteria in managing projects.
  - Quantitative objectives are based on the needs of the customer, end users, organization, and process implementers.
  - Quality and process performance is understood in statistical terms and is managed throughout the life of projects.

Maturity Levels

- Level 4: Quantitatively Managed
  - For selected subprocesses, specific measures of process performance are collected and statistically analyzed.
    - When selecting subprocesses for analyses, it is critical to understand the relationships between different subprocesses and their impact on achieving the objectives for quality and process performance. Such an approach helps to ensure that subprocess monitoring using statistical and other quantitative techniques is applied to where it has the most overall value to the business. Process performance baselines and models can be used to help set quality and process performance objectives that help achieve business objectives.

Maturity Levels

- Level 4: Quantitatively Managed
  - A critical distinction between maturity levels 3 and 4 is the predictability of process performance.
  - At maturity level 4, the performance of projects and selected subprocesses is controlled using statistical and other quantitative techniques, and predictions are based, in part, on a statistical analysis of fine-grained process data.

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Maturity Levels

- Level 5: Optimizing
  - At maturity level 5, an organization continually improves its processes based on a quantitative understanding of its business objectives and performance needs.
  - The organization uses a quantitative approach to understand the variation inherent in the process and the causes of process outcomes.

Maturity Levels

- Level 5: Optimizing (continued)
  - Maturity level 5 focuses on continually improving process performance through incremental and innovative process and technological improvements.
  - The organization's quality and process performance objectives are established, continually revised to reflect changing business objectives and organizational performance, and used as criteria in managing process improvement. The effects of deployed process improvements are measured using statistical and other quantitative techniques and compared to quality and process performance objectives. The project's defined processes, the organization's set of standard processes, and supporting technology are targets of measurable improvement activities.

Maturity Levels

- Level 5: Optimizing (continued)
  - A critical distinction between maturity levels 4 and 5 is the focus on managing and improving organizational performance.
  - At maturity level 4, the organization and projects focus on understanding and controlling performance at the subprocess level and using the results to manage projects.
  - At maturity level 5, the organization is concerned with overall organizational performance using data collected from multiple projects. Analysis of the data identifies shortfalls or gaps in performance. These gaps are used to drive organizational process improvement that generates measurable improvement in performance.

Advancing through Maturity Levels

- Organizations can achieve progressive improvements in their maturity by achieving control first at the project level and continuing to the most advanced level—organization-wide performance management and continuous process improvement—using both qualitative and quantitative data to make decisions.

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Process Areas

- A process area is a cluster of related practices in an area that, when implemented collectively, satisfies a set of goals considered important for making significant improvement in that area.

Process Areas

- Causal Analysis and Resolution (CAR)
- Configuration Management (CM)
- Decision Analysis and Resolution(DAR)
- Integrated Project Management (IPM)
- Measurement and Analysis (MA)
- Organizational Process Definition (OPD)
- Organizational Process Focus (OPF)
- Organizational Performance Management (OPM)
- Organizational Process Performance (OPP)
- Organizational Training (OT)
- Product Integration (PI)

- Project Monitoring and Control (PMC)
- Project Planning (PP)
- Process and Product Quality Assurance (PPQA)
- Quantitative Project Management (QPM)
- Requirements Development (RD)
- Requirements Management (REQM)
- Risk Management (RSKM)
- Supplier Agreement Management (SAM)
- Technical Solution (TS)
- Validation (VAL)
- Verification (VER)

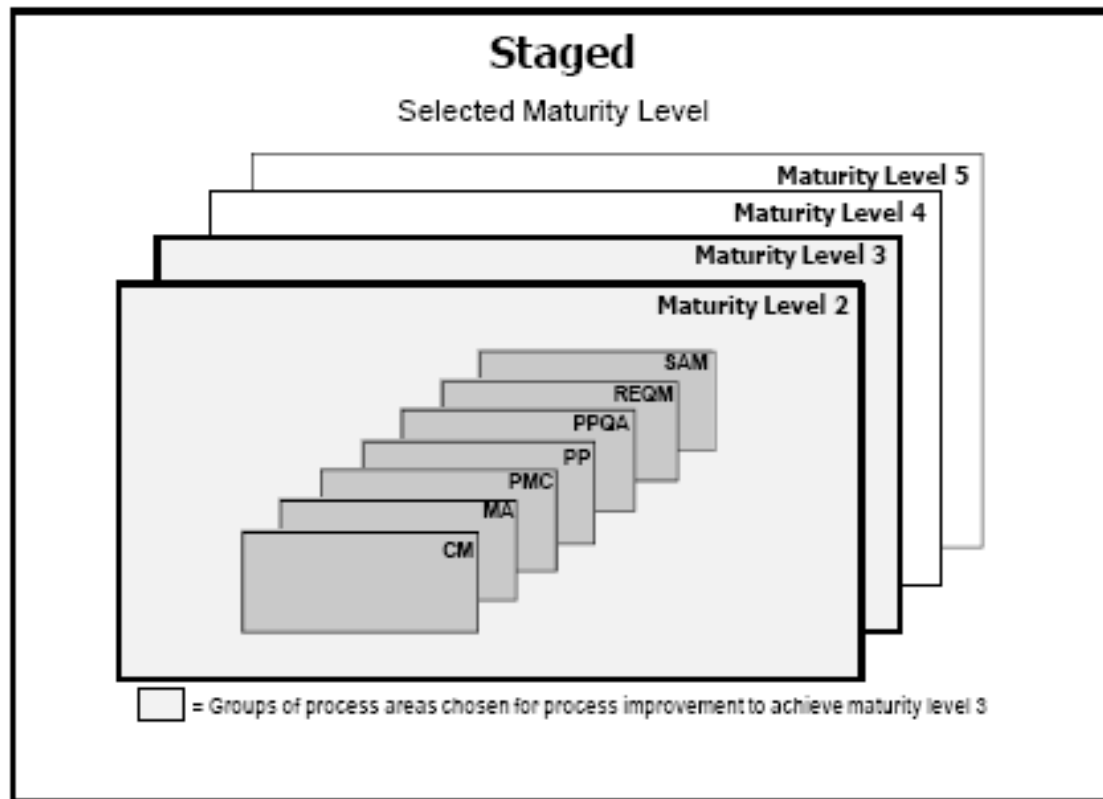*Advanced Software Process © Dave Garcia-Gomez @ CSU Fullerton*

Process Areas

- Process areas are viewed differently in the two representations.

- Process areas in the Continuous Representation
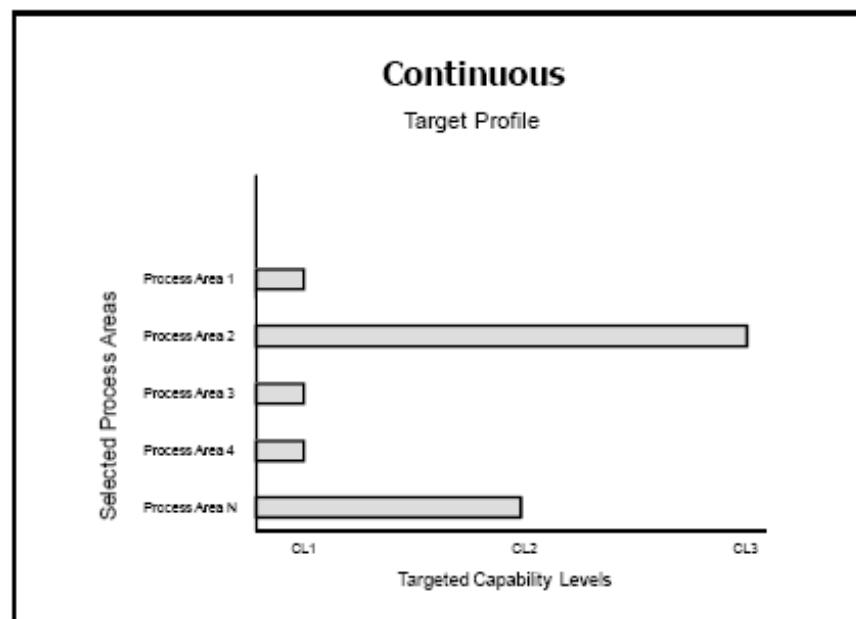
Process Areas

- Process areas in the Staged Representation

Process Areas

Process Areas	Category	ML
Causal Analysis and Resolution (CAR)	Support	5
Configuration Management (CM)	Support	2
Decision Analysis and Resolution (DAR)	Support	3
Integrated Project Management (IPM)	Project Management	3
Measurement and Analysis (MA)	Support	2
Organizational Process Definition (OPD)	Process Management	3
Organizational Process Focus (OPF)	Process Management	3
Organizational Performance Management (OPM)	Process Management	5
Organizational Process Performance (OPP)	Process Management	4
Organizational Training (OT)	Process Management	3
Product Integration (PI)	Engineering	3
Project Monitoring and Control (PMC)	Project Management	2
Project Planning (PP)	Project Management	2
Process and Product Quality Assurance (PPQA)	Support	2
Quantitative Project Management (QPM)	Project Management	4
Requirements Development (RD)	Engineering	3
Requirements Management (REQM)	Engineering	2
Risk Management (RSKM)	Project Management	3
Supplier Agreement Management (SAM)	Project Management	2
Technical Solution (TS)	Engineering	3
Validation (VAL)	Engineering	3
Verification (VER)	Engineering	3

Capability Level Profile vs. Maturity Level Rating

- The SCAMPI method is used to appraise organizations using CMMI, and one result of an appraisal is a rating [SEI 2011a, Ahern 2005].

- If the <u>continuous representation</u> is used for an appraisal, the rating is a "capability level profile."

- If the <u>staged representation</u> is used for an appraisal, the rating is a "maturity level rating" (e.g., maturity level 3).

Equivalent Staging

- Equivalent staging is a way to compare results from using the continuous representation to results from using the staged representation.

  – In essence, if you measure improvement relative to selected process areas using capability levels in the continuous representation, how do you translate that work into maturity levels? Is this translation possible?

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Equivalent Staging

- A capability level profile is a list of process areas and the corresponding capability level achieved for each.

- This profile enables an organization to track its capability level by process area.

- The profile is called an "achievement profile" when it represents the organization's actual progress for each process area.

- Alternatively, the profile is called a "target profile" when it represents the organization's planned process improvement objectives.

Equivalent Staging

- Example: Combined Target and Achievement Profile
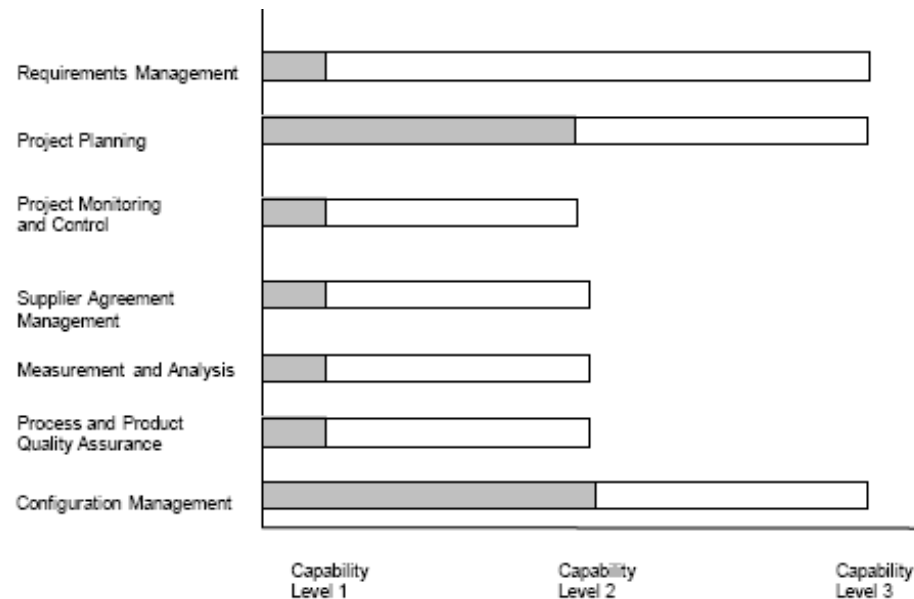
This figure illustrates a combined target and achievement profile.
The gray portion of each bar represents what has been achieved.
The unshaded portion represents what remains to be accomplished to meet the target profile.

Equivalent Staging

- Equivalent staging enables an organization using the continuous representation to convert a capability level profile to the associated maturity level rating.

Target Profiles and Equivalent Staging

To achieve maturity level 2, all process areas assigned to maturity level 2 must achieve capability level 2 or 3.

Name	Abbr	ML	CL1	CL2	CL3
Requirement Management	REQM	2			
Project Planning	PP	2			
Project Monitoring and Control	PMC	2		Target Profile 2	
Supplier Agreement Management	SAM	2			
Measurement and Analysis	MA	2			
Process and Product Quality Assurance	PPQA	2			
Configuration Management	CM	2			
Requirements Development	RD	3			
Technical Solution	TS	3			
Product Integration	PI	3			
Verification	VER	3			
Validation	VAL	3			
Organizational Process Focus	OPF	3			
Organizational Process Definition + IPPD	OPD	3			
Organizational Training	OT	3			
Integrated Project Management + IPPD	IPM	3			
Risk Management	RSKM	3		Target Profile 3	
Decision Analysis and Resolution	DAR	3			
Organizational Process Performance	OPP	4		Target Profile 4	
Quantitative Project Management	QPM	4			
Organizational Performance Management	OPM	5		Target Profile 5	
Causal Analysis and Resolution	CAR	5			

Equivalent Staging

- The following rules summarize equivalent staging:
  - To achieve maturity level 2, all process areas assigned to maturity level 2 must achieve capability level 2 or 3.
  - To achieve maturity level 3, all process areas assigned to maturity levels 2 and 3 must achieve capability level 3.
  - To achieve maturity level 4, all process areas assigned to maturity levels 2, 3, and 4 must achieve capability level 3.
  - To achieve maturity level 5, all process areas must achieve capability level 3.

Achieving High Maturity

- When using the staged representation, you attain high maturity when you achieve maturity level 4 or 5.

- Achieving maturity level 4 involves implementing all process areas for maturity levels 2, 3, and 4.

- Likewise, achieving maturity level 5 involves implementing all process areas for maturity levels 2, 3, 4, and 5.

Achieving High Maturity

- When using the continuous representation, you attain high maturity using the equivalent staging concept.

- High maturity that is equivalent to staged maturity level 4 using equivalent staging is attained when you achieve capability level 3 for all process areas except for Organizational Performance Management (OPM) and Causal Analysis and Resolution (CAR).

- High maturity that is equivalent to staged maturity level 5 using equivalent staging is attained when you achieve capability level 3 for all process areas.

Relationships Among Process Areas

- Four Categories of CMMI PAs

Four Categories of CMMI PAs

- Process Management

- Project Management

- Engineering

- Support

Process Management

- Process Management process areas contain the cross-project activities related to defining, planning, deploying, implementing, monitoring, controlling, appraising, measuring, and improving processes.

- The Process Management PAs:
  - Organizational Process Definition (OPD)
  - Organizational Process Focus (OPF)
  - Organizational Performance Management (OPM)
  - Organizational Process Performance (OPP)
  - Organizational Training (OT)

Process Management

- Basic Process Management Process Areas

OPD = Organizational Process Definition
OPF = Organizational Process Focus
OT = Organizational Training
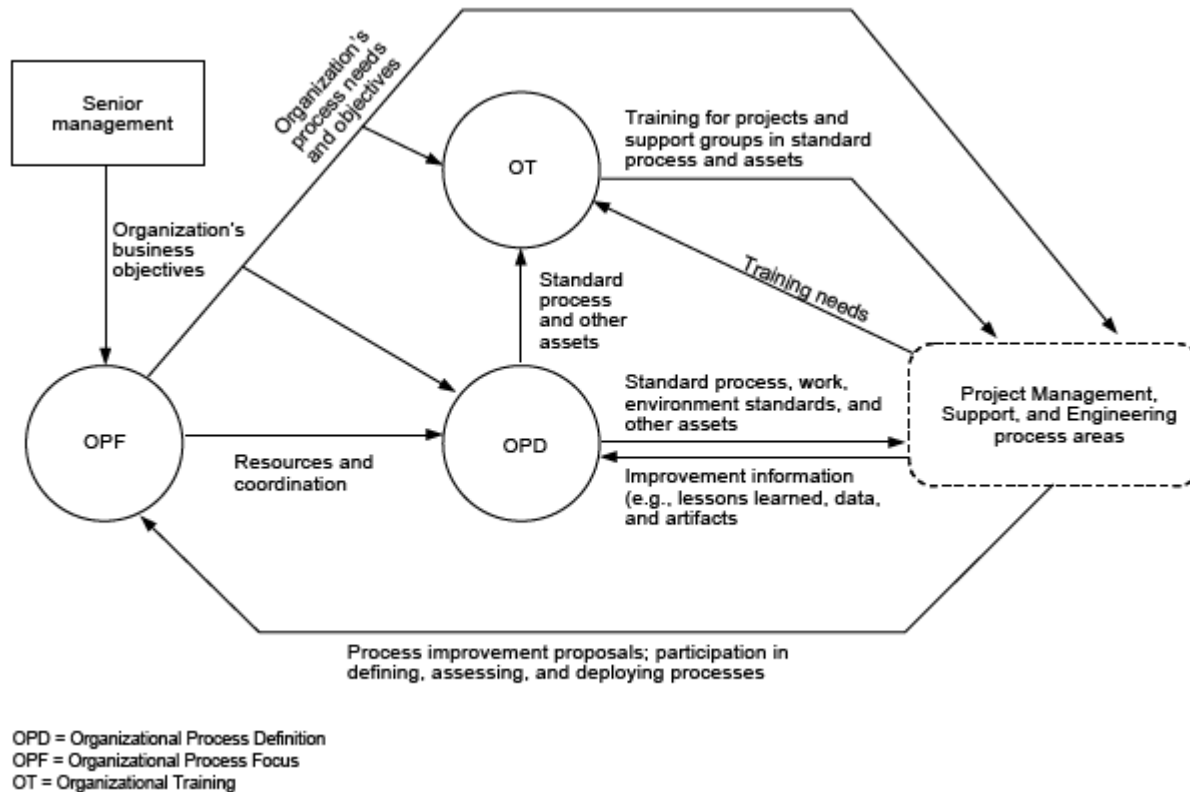
Process Management

- Advanced Process Management Process Areas

OPM = Organizational Performance Management
OPP = Organizational Process Performance
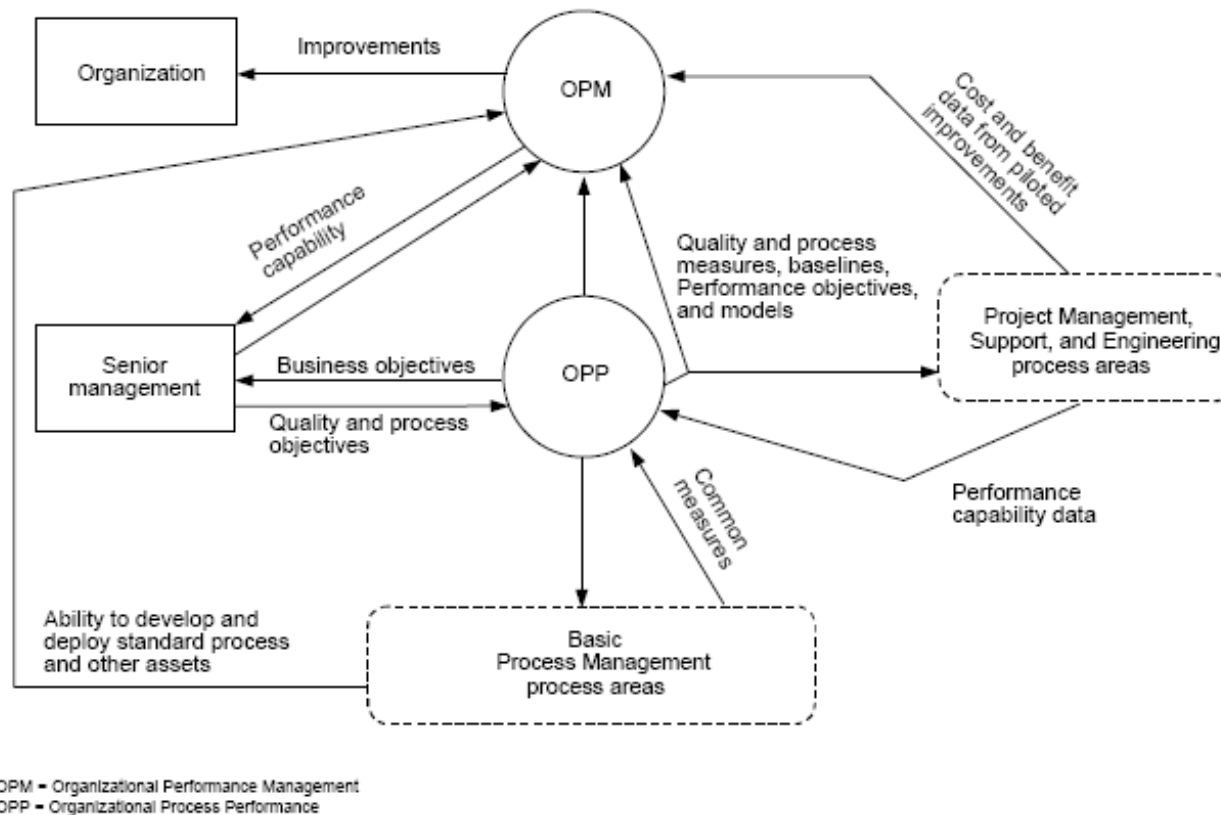
Project Management

- Project Management process areas cover the project-management activities related to planning, monitoring, and controlling the project.
- The Project Management PAs:
  - Integrated Project Management (IPM)
  - Project Monitoring and Control (PMC)
  - Project Planning (PP)
  - Quantitative Project Management (QPM)
  - Requirements Management (REQM)
  - Risk Management (RSKM)
  - Supplier Agreement Management (SAM)

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Relationships among Process Areas

- Basic Project Management Process Areas

PMC = Project Monitoring and Control
PP = Project Planning
REQM = Requirements Management
SAM = Supplier Agreement Management
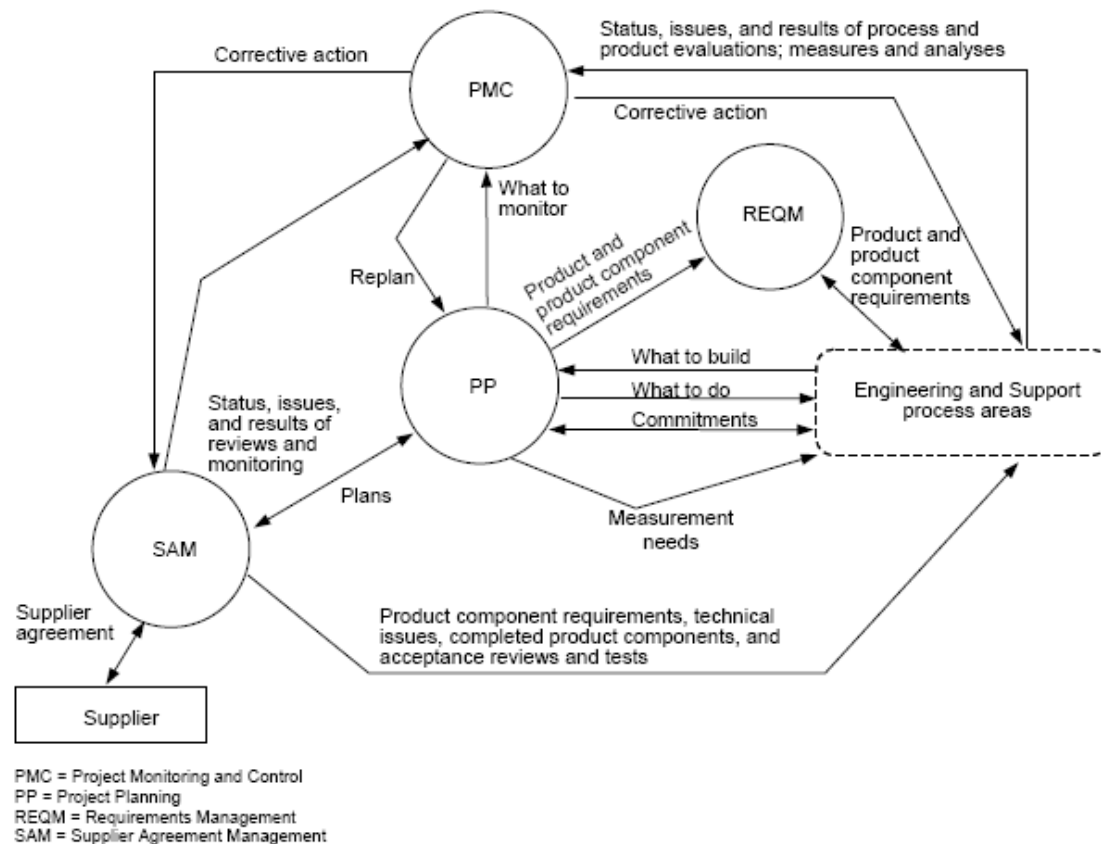
Relationships among Process Areas

- Advanced Project Management Process Areas
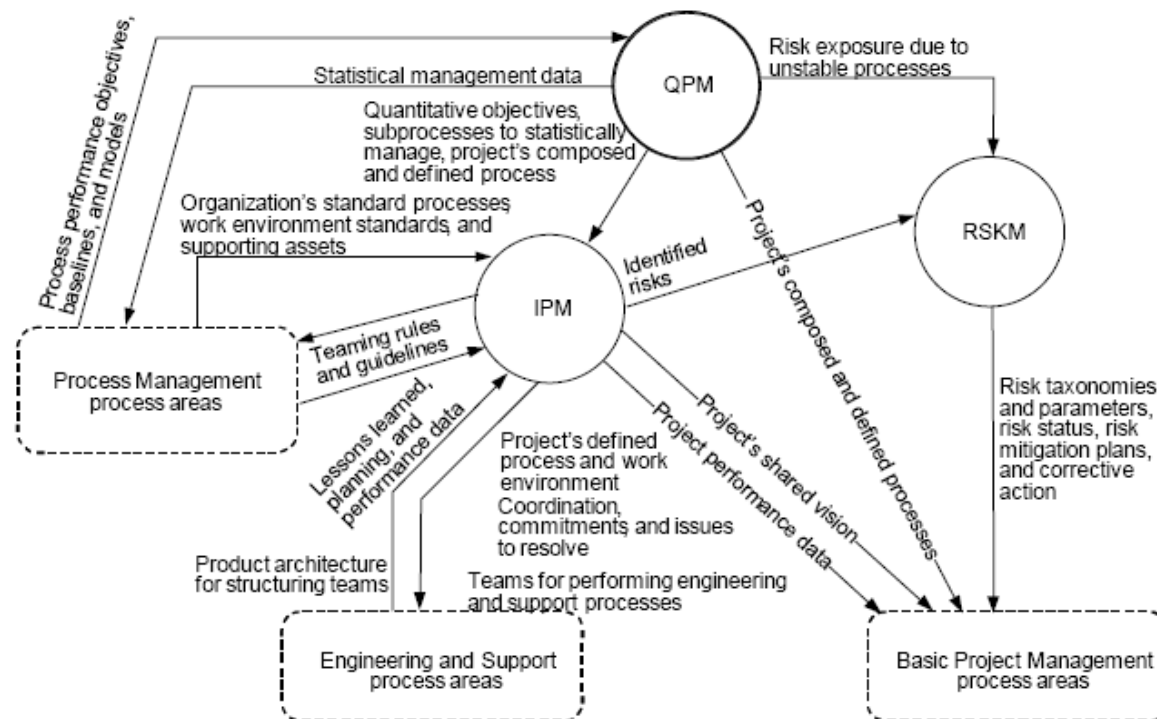
IPM= Integrated Project Management
QPM = Quantitative Project Management
RSKM = Risk Management

Engineering

- Engineering process areas cover the development and maintenance activities that are shared across engineering disciplines.

- The Engineering PAs were written using general engineering terminology so that any technical discipline involved in the product development process (e.g., SE, system engineering) can use them for process improvement.

Engineering

- The Engineering PAs:
  - Product Integration (PI)
  - Requirement Development (RD)
  - Technical Solution (TS)
  - Validation (VAL)
  - Verification (VER)

Relationships among Process Areas

- Engineering Process Areas
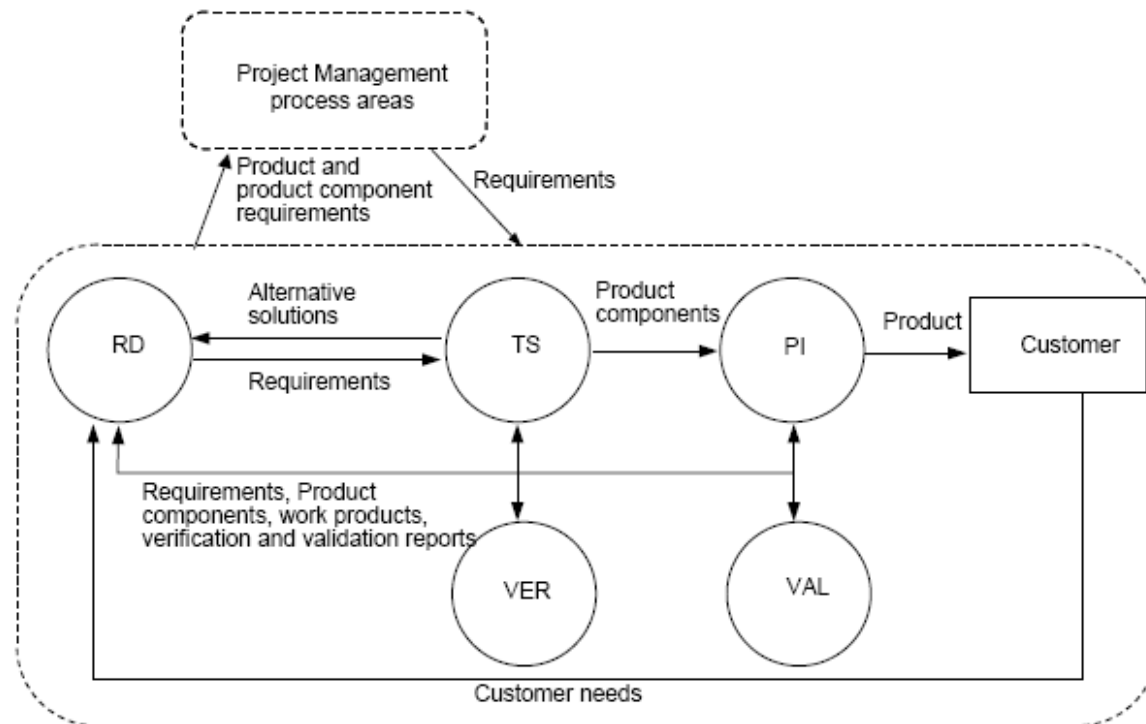
PI = Product Integration
RD = Requirements Development
TS = Technical Solution
VAL = Validation
VER = Verification

Support

- Support process areas cover the activities that support product development and maintenance.

- The Support PAs address processes that are used in the context of performing other processes.
  - Causal Analysis and Resolution (CAR)
  - Configuration Management (CM)
  - Decision Analysis and Resolution (DAR)
  - Measurement and Analysis (MA)
  - Process and Product Quality Assurance (PPQA)

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Basic Support Process Areas

- Basic Support Process Areas
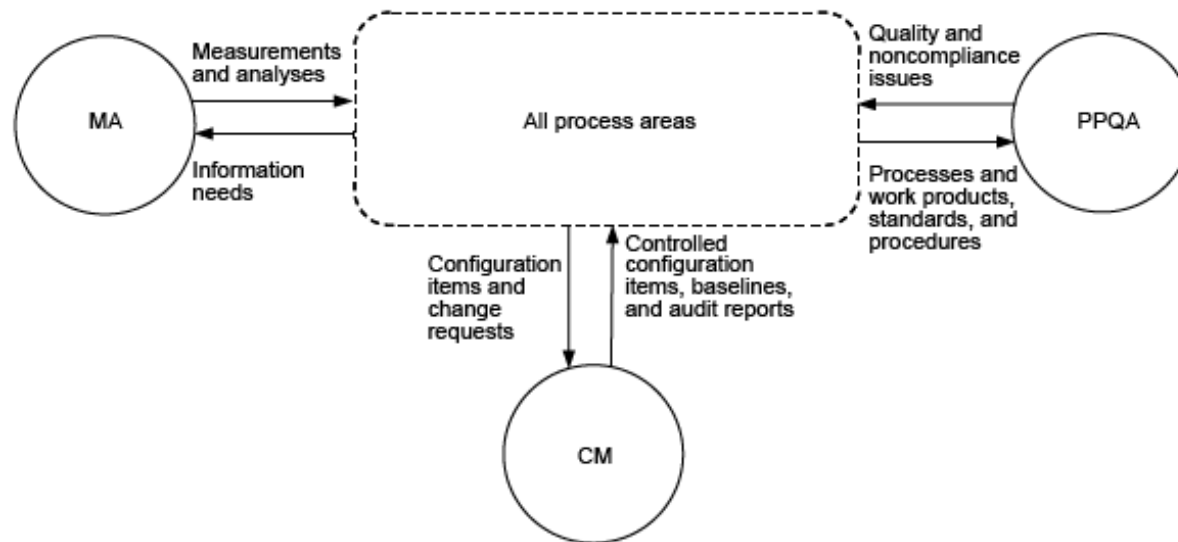
CM = Configuration Management
MA = Measurement and Analysis
PPQA = Process and Product Quality Assurance

Basic Support Process Areas

• Advanced Support Process Areas

CAR = Causal Analysis and Resolution
DAR = Decision Analysis and Resolution

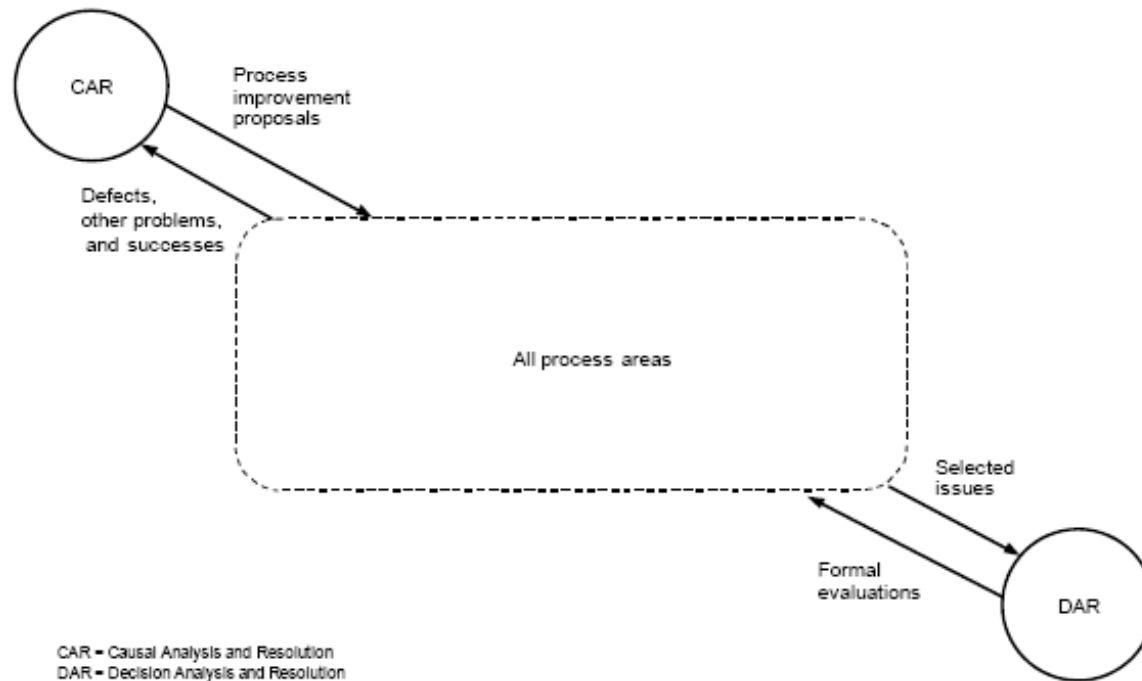| Process Areas	Category	ML
Causal Analysis and Resolution (CAR)	Support	5
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Decision Analysis and Resolution (DAR)	Support	3
Integrated Project Management (IPM)	Project Management	3
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Organizational Process Focus (OPF)	Process Management	3
Organizational Performance Management (OPM)	Process Management	5
Organizational Process Performance (OPP)	Process Management	4
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Project Monitoring and Control (PMC)	Project Management	2
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Requirements Management (REQM)	Engineering	2
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Technical Solution (TS)	Engineering	3
Validation (VAL)	Engineering	3
Verification (VER)	Engineering	3

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Process Areas	Category	ML
■ Requirements Management (REQM)	Project Management	2
■ Project Planning (PP)	Project Management	2
■ Project Monitoring and Control (PMC)	Project Management	2
■ Supplier Agreement Management (SAM)	Project Management	2
■ Measurement and Analysis (MA)	Support	2
■ Process and Product Quality Assurance (PPQA)	Support	2
■ Configuration Management (CM)	Support	2
■ Requirements Development (RD)	Engineering	3
■ Technical Solution (TS)	Engineering	3
■ Product Integration (PI)	Engineering	3
■ Verification (VER)	Engineering	3
■ Validation (VAL)	Engineering	3
■ Organizational Process Focus (OPF)	Process Management	3
■ Organizational Process Definition (OPD)	Process Management	3
■ Organizational Training (OT)	Process Management	3
■ Integrated Project Management (IPM)	Project Management	3
■ Risk Management (RSKM)	Project Management	3
■ Decision Analysis and Resolution (DAR)	Support	3
■ Organizational Process Performance (OPP)	Process Management	4
■ Quantitative Project Management (QPM)	Project Management	4
■ Organizational Performance Management (OPM)	Process Management	5
■ Causal Analysis and Resolution (CAR)	Support	5

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PAs, MLs, Categories

	Process Management	Project Management	Engineering	Support
ML 5	OPM			CAR
ML 4	OPP	QPM		
ML 3	OPF OPD OT	IPM RSKM	RD TS PI VER VAL	DAR
ML 2		PP PMC REQM SAM		MA PPQA CM

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Using CMMI Models

- Interpreting CMMI Models
- Appraisals and Benchmarking

Interpreting CMMI Models

- CMMI describes the best practices of organizations.

- These best practices can be used by organizations to improve their processes for developing, acquiring, and maintaining products and services.

- While a new enterprise might wish to establish its processes using these best practices, they are more commonly of interest to organizations that are seeking to improve their existing processes.

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Interpreting CMMI Models

- Such organizations must use professional judgment to interpret CMMI practices.

- As you begin using a CMMI model for improving processes, you should map your processes to CMMI process areas.

- This mapping enables you to track your organization's level of conformance to the CMMI model you are using and to easily identify opportunities for improvement.

Selections That Influence Your Process Improvement Program

- You must make three selections to apply CMMI to your organization for process improvement:

  1. Select a part of the organization.

  2. Select a model.

  3. Select a representation.

Interpreting CMMI When Using Agile Approaches

- Because CMMI does not endorse any particular approach to development, little information that is approach-specific is provided.

- Therefore, those who don't have prior experience implementing CMMI in situations similar to the one they are now in may find interpretation non-intuitive.

Interpreting CMMI When Using Agile Approaches

- To help those who use Agile methods to interpret CMMI practices in their environments, notes have been added to selected process areas.

- These notes are added, usually in the introductory notes, to the following process areas in CMMI-DEV: CM, PI, PMC, PP, PPQA, RD, REQM, RSKM, TS, and VER.

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Interpreting CMMI When Using Agile Approaches

- All of the notes begin with the words, "In Agile environments" and are in example boxes to help you to easily recognize them and remind you that these notes are examples of how to interpret practices and therefore are neither necessary nor sufficient for implementing the process area.

Interpreting CMMI When Using Agile Approaches

- Multiple Agile approaches exist.

- The phrases "Agile environment" and "Agile method" are shorthand for any development or management approach that adheres to the *Manifesto for Agile Development* [Beck 2001].

Interpreting CMMI When Using Agile Approaches

- Multiple Agile approaches exist.

- The phrases "Agile environment" and "Agile method" are shorthand for any development or management approach that adheres to the *Manifesto for Agile Development* [Beck 2001].

Interpreting CMMI When Using Agile Approaches

- Some general background and motivation for the guidance given on Agile development approaches are found in the SEI technical note *CMMI or Agile: Why Not Embrace Both!* [Glazer 2008].

Using CMMI Appraisals

- Many organizations find value in measuring their progress by conducting an appraisal and earning a maturity level rating or a capability level achievement profile.
  - To determine how well the organization's processes compare to CMMI best practices and identify areas where improvement can be made
  - To inform external customers and suppliers about how well the organization's processes compare to CMMI best practices
  - To meet the contractual requirements of one or more customers

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Appraisals and Benchmarking

- Appraisal teams use CMMI to guide their identification and prioritization of findings.

- These findings, with guidance provided by CMMI practices, are used to plan improvements for the organization.

Appraisal Requirements for CMMI

- The Appraisal Requirements for CMMI (ARC) document describes the requirements for several types of appraisals.

- A full benchmarking appraisal is defined as a Class A appraisal method. Less formal methods are defined as Class B or Class C methods.

- The ARC document was designed to help improve consistency across appraisal methods and to help appraisal method developers, sponsors, and users understand the tradeoffs associated with various methods.

  https://resources.sei.cmu.edu/library/asset-view.cfm?assetid=9959

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SCAMPI Appraisal Methods

- The SCAMPI A appraisal method is the generally accepted method used for conducting ARC Class A appraisals using CMMI models.

  – The SCAMPI A Method Definition Document (MDD) defines rules for ensuring the consistency of SCAMPI A appraisal ratings [SEI 2011a].

    • For benchmarking against other organizations, appraisals must ensure consistent ratings.

    • The achievement of a specific maturity level or the satisfaction of a process area must mean the same thing for different appraised organizations.

SCAMPI Appraisal Methods

- The SCAMPI family of appraisals includes Class A, B, and C appraisal methods.
    - The SCAMPI A appraisal method is the officially recognized and most rigorous method. SCAMPI B and C appraisal methods provide organizations with improvement information that is less formal than the results of a SCAMPI A appraisal, but nonetheless helps the organization to identify improvement opportunities.

        https://resources.sei.cmu.edu/library/asset-view.cfm?assetid=9959

Appraisal Considerations

- Choices that affect a CMMI-based appraisal include the following:
  - CMMI model
  - Appraisal scope, including the organizational unit to be appraised, the CMMI process areas to be investigated, and the maturity level or capability levels to be appraised
  - Appraisal method
  - Appraisal team leader and team members
  - Appraisal participants selected from the appraisal entities to be interviewed
  - Appraisal outputs (e.g., ratings, instantiation-specific findings)
  - Appraisal constraints (e.g., time spent on site)

Appraisal Considerations

- The following appraisal principles for CMMI are the same as those principles used in appraisals for other process improvement models:
  - Senior management sponsorship
  - A focus on the organization's business objectives
  - Confidentiality for interviewees
  - Use of a documented appraisal method
  - Use of a process reference model (e.g., a CMMI model)
  - A collaborative team approach
  - A focus on actions for process improvement

Appraisals and Benchmarking

- The International Organization for Standardization and International Electro-technical Commission (ISO/IEC) Technical Report 15504 is an emerging standard for SW process assessment.
  - **SPICE (Software Process Improvement and Capability dEtermination)**
  - The CMMI models and SCAMPI were written to support the conduct of appraisals that conform to the 1998 version of Technical Report 15504.
  - Sponsors interested in performing an ISO/IEC 15504-conformant CMMI appraisal must provide necessary information including a demonstration of compatibility to support their needs.

SPICE (Software Process Improvement and Capability dEtermination)

- ISO/IEC TR 15504 consists of the following parts, under the general title Information Technology - Software Process Assessment:
  - Part 1: Concepts and introductory guide
  - Part 2: A reference model for processes and process capability
  - Part 3: Performing an assessment
  - Part 4: Guide to performing assessments
  - Part 5: An assessment model and indicator guidance
  - Part 6: Guide to competency of assessors
  - Part 7: Guide for use in process improvement
  - Part 8: Guide for use in determining supplier process capability
  - Part 9: Vocabulary
  - Part 10: Safety extension

SPICE (Software Process Improvement and Capability dEtermination)

- ISO/IEC TR 15504 consists of the following parts, under the general title Information Technology - Software Process Assessment:
  - https://www.iso.org/standard/38932.html
  - http://www.lc-stars.com/assessmentbooks.html
  - http://www.itq.ch/pdf/spi/SPICE_Future.pdf
  - http://www.hms.org/pub/synprove/SPiCE121/SupplierCapabilityAssessment.pdf
  - http://www.softwareresearch.net/fileadmin/src/docs/teaching/SS03/PM/1T3ewa.pdf
  - http://www.softwareresearch.net/fileadmin/src/docs/teaching/SS03/SE2/SPICE.I.pdf

Generic Goals and Generic Practices, and the Process Areas

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Goals and Practices

- The CMMI defines each process area in terms of specific goals (SG) and the specific practices (SP).

  - SGs establish the characteristics that must exist if the activities implied by a process area are to be effective.

  - SPs refine a goal into a set of process-related activities.

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Goals and Practices

- In addition to SGs and SPs, the CMMI also defines a set of three generic goals (GG) and related practices (GP) for each process area.

- Each of the three GGs corresponds to one of the three capability levels.

- Hence, to achieve a particular capability level, the generic goal for that level and the generic practices that correspond to that goal must be achieved.

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Process Institutionalization

- Institutionalization means that the process is ingrained in the way the work is performed.
  - "That's the way we do things around here."
- The organization builds an infrastructure that contains effective, usable, and consistently applied processes.
  - The organizational culture conveys the process, and management nurtures the culture.
  - Culture is conveyed through role models and recognition.
  - Institutionalized processes endure after the people who originally defined them have gone.

Generic Goals and Institutionalization

- The degree of institutionalization is embodied in the generic goals and expressed in the names of the processes associated with each goal as indicated in the table below:

Generic Goals	Progression of Processes
GG1:Achieve Specific Goals	Performed Process
GG2:Institutionalize a Managed Process	Managed Process
GG3:Institutionalize a Defined Process	Defined Process

Generic Goals

GGs and GPs
GG 1 Achieve Specific Goals
GP 1.1 Perform Specific Practices
GG 2 Institutionalize a Managed Process
GP 2.1 Establish an Organizational Policy
GP 2.2 Plan the Process (PP)
GP 2.3 Provide Resources (PP SP 2.4 Plan for Project 'sResource)
GP 2.4 Assign Responsibility (PP SP 2.4 Plan for Project's Resource)
GP 2.5 Train People (OT, PP SP 2.5 Plan Needed Knowledge and Skills)
GP 2.6 Control Work Products (CM)
GP 2.7 Identify and Involve Relevant Stakeholders (PP, PMC, IPM)
GP 2.8 Monitor and Control the Process (PMC, MA)
GP 2.9 Objectively Evaluate Adherence (PPQA)
GP 2.10 Review Status with Higher Level Management (PMC)
GG 3 Institutionalize a Defined Process
GP 3.1 Establish a Defined Process (IPM, OPD)
GP 3.2 Collect Process Related Experiences (IPM, OPF, OPD)

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Mat. Level	Focus	Process Areas
5. Optimizing	Continuous process improvement	Organizational Performance Management (OPM) Causal Analysis and Resolution (CAR)
4. Quantitatively Managed	Quantitative management	Organizational Process Performance (OPP) Quantitative Project Management (QPM)
3. Defined	Process standardization	Requirements Development (RD), Technical Solution (TS), Product Integration (PI), Verification (VER), Validation (VAL), Organizational Process Focus (OPF), Organizational Process Definition (OPD), Organizational Training (OT), Integrated Project Management (IPM), Risk Management (RSKM), Decision Analysis and Resolution (DAR)
2. Managed	Basic project management	Requirement Management (REQM), Project Planning (PP), Project Monitoring and Control (PMC), Supplier Agreement Management (SAM), Measurement and Analysis (MA), Process and Product Quality Assurance (PPQA), Configuration Management (CM)

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Comparison of Capability and Maturity Levels

Level	Continuous Representation Capability Levels	Staged Representation Maturity Levels
0	Incomplete	-
1	Performed	Initial
2	Managed	Managed
3	Defined	Defined
4		Quantitatively Managed
5		Optimizing

Process Areas in Detail

- Process Areas Presented in the Staged Representation

Process Areas Presented in the Staged Representation: Maturity Level 2

- Requirements Management (REQM)

- Project Planning (PP)

- Project Monitoring and Control (PMC)

- Supplier Agreement Management (SAM)

- Measurement and Analysis (MA)

- Process and Product Quality Assurance (PPQA)

- Configuration Management (CM)

Process Areas	Category	ML
▪ **Requirements Management (REQM)**	**Project**	**2**
▪ **Project Planning (PP)**	**Project**	**2**
▪ **Project Monitoring and Control (PMC)**	**Project**	**2**
▪ **Supplier Agreement Management (SAM)**	**Project**	**2**
▪ **Measurement and Analysis (MA)**	**Support**	**2**
▪ **Process and Product Quality Assurance**	**Support**	**2**
▪ **Configuration Management (CM)**	**Support**	**2**
▪ Requirements Development (RD)	Engineering	3
▪ Technical Solution (TS)	Engineering	3
▪ Product Integration (PI)	Engineering	3
▪ Verification (VER)	Engineering	3
▪ Validation (VAL)	Engineering	3
▪ Organizational Process Focus (OPF)	Process Management	3
▪ Organizational Process Definition (OPD)	Process Management	3
▪ Organizational Training (OT)	Process Management	3
▪ Integrated Project Management (IPM)	Project Management	3
▪ Risk Management (RSKM)	Project Management	3
▪ Decision Analysis and Resolution (DAR)	Support	3
▪ Organizational Process Performance (OPP)	Process Management	4
▪ Quantitative Project Management (QPM)	Project Management	4
▪ Organizational Performance Management (OPM)	Process Management	5
▪ Causal Analysis and Resolution (CAR)	Support	5

Target Profiles and Equivalent Staging

To achieve maturity level 2, all process areas assigned to maturity level 2 must achieve capability level 2 or 3.

Name	Abbr	ML	CL1	CL2	CL3
Requirement Management	REQM	2			
Project Planning	PP	2			
Project Monitoring and Control	PMC	2		Target Profile 2	
Supplier Agreement Management	SAM	2			
Measurement and Analysis	MA	2			
Process and Product Quality Assurance	PPQA	2			
Configuration Management	CM	2			
Requirements Development	RD	3			
Technical Solution	TS	3			
Product Integration	PI	3			
Verification	VER	3			
Validation	VAL	3			
Organizational Process Focus	OPF	3			
Organizational Process Definition + IPPD	OPD	3			
Organizational Training	OT	3			
Integrated Project Management + IPPD	IPM	3			
Risk Management	RSKM	3		Target Profile 3	
Decision Analysis and Resolution	DAR	3			
Organizational Process Performance	OPP	4		Target Profile 4	
Quantitative Project Management	QPM	4			
Organizational Performance Management	OPM	5		Target Profile 5	
Causal Analysis and Resolution	CAR	5			

Requirement Management (REQM)

- An Project Management PA at ML 2

- The purpose of Requirements Management (REQM) is to manage requirements of the project's products and product components and to ensure alignment between those requirements and the project's plans and work products.

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Requirement Management (REQM)

- Specific Goals and Practices
- SG 1 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

Project Planning (PP)

- A Project Management PA at ML 2
- The purpose of Project Planning (PP) is to establish and maintain plans that define project activities.
- The Project Planning process area involves:
  - Developing the project plan
  - Interacting with stakeholders appropriately
  - Getting commitment to the plan
  - Maintaining the plan

Project Planning (PP)

- Specific Goals and Practices

- SG 1 Establish Estimates

- SG 2 Develop a Project Plan

- SG 3 Obtain Commitment to the Plan

Project Planning (PP)

- **SG 1 Establish Estimates**
  - SP 1.1 Estimate 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 of Effort and Cost
- **SG 2 Develop a Project Plan**
  - SP 2.x ...
- **SG 3 Obtain Commitment to the Plan**
  - SP 3.x ...

Project Planning (PP)

- SG 1 Establish Estimates
  - SP 1.1 Estimate the Scope of the Project
    - Establish a top-level work breakdown structure (WBS) to estimate the scope of the project.
    - Example Work Products
      - Task description, work package descriptions, WBS
    - Sub-practices
      1. Develop a WBS.
      2. Define the work packages in sufficient detail so that estimates of project tasks, responsibilities, and schedule can be specified.
      3. Identify product or product components to be externally acquired.
      4. Identify work products to be reused.
  - SP 1.2 …
  - …

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Project Planning (PP)

- **Generic Practices by Goal**
  - **GG 1 Achieve Specific Goals**
    - GP 1.1 Perform Specific Practices
  - **GG 2 Institutionalize a Managed Process**
    - GP 2.1 Establish an Organizational Policy
    - GP 2.2 Plan the Process
    - …
  - **GG 3 Institutionalize a Defined Process**
    - …

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Project Planning (PP)
GGs and GPs: Related PAs

- GG 1 Achieve Specific Goals
  - GP 1.1 Perform Specific Practices
- GG 2 Institutionalize a Managed Process
  - GP 2.1 Establish an Organizational Policy
  - GP 2.2 Plan the Process (PP)
  - GP 2.3 Provide Resources (PP SP 2.4 Plan for Project Resource)
  - GP 2.4 Assign Responsibility (PP SP 2.4 Plan for Project Resource)
  - GP 2.5 Train People (OT, PP SP 2.5 Plan for Needed Knowledge and Skills)
  - GP 2.6 Control Work Products (CM)
  - GP 2.7 Identify and Involve Relevant Stakeholders (PP, PMC, IPM)
  - PMC SP 1.5 Monitor Stakeholder Involvement
  - GP 2.8 Monitor and Control the Process (PMC, MA)
  - GP 2.9 Objectively evaluate adherence (PPQA)
  - GP 2.10 Review Status with Higher Level Management (PMC)
    - PMC SP 1.6 Conduct Progress Reviews
    - PMC SP 1.7 Conduct Milestone Reviews

Project Monitoring and Control (PMC)

- A Project Management PA at ML 2
- The purpose of Project Monitoring and Control (PMC) is to provide an understanding of the project's progress so that appropriate corrective actions can be taken when the project's performance deviates significantly from the plan.
- Project plan
  - The overall plan for controlling the project
- Corrective actions
  - Re-planning, establishing new agreements, including additional mitigation activities in the plan

Project Monitoring and Control (PMC) Specific Goals and Practices

- 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 Stakeholders 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 Actions

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Project Monitoring and Control (PMC) Assessment: Objective Evidence

PMC SG	PMC SP	Objective Evidence Doc. & Interviews	Comments
PMC SG 1 Monitor the Project Against the Plan	PMC SP 1.1 Monitor Project Planning Parameters	Project Plan. Performance and Deviation. Progress against Schedule. Interviews.	Monitor progress, cost, effort, tasks and work products. Monitor resources provided and use properly.
	PMC SP 1.2 Monitor Commitments	Commitments Review. Interviews.	A new commitment is signed on the document when there is any change.
	PMC SP 1.3 Monitor Project Risks	Project Risk Monitoring. Risk Mitigation Plan. Interviews.	Communicate with the stakeholders and find a change in risk priority.
	PMC SP 1.4 Monitor Data Management	Data Management. Tools and Operation. Interviews.	Periodically review data management activities. Provide tools and training.
	PMC SP 1.5 Monitor Stakeholder Involvement	Stakeholder Involvement. Interviews.	Identify and document significant issues and their impacts.
	PMC SP 1.6 Conduct Progress Reviews	Project Review. Change Request and Resolution (Record). Change Chart (Chart). Interviews.	Review the results of collecting and analyzing measures for controlling the project.
	PMC SP 1.7 Conduct Milestone Reviews	Milestone Review. Interviews.	At the end of each time-boxed iteration and phase, conduct reviews with stakeholders. Update the next iteration and phase plan.

Project Monitoring and Control (PMC) Assessment: Objective Evidence

PMC SG	PMC SP	Objective Evidence Doc. & Interviews	Comments
SG 2 Manage Corrective Action to Closure	PMC SP 2.1 Analyze Issues	List of Issues. Interviews.	Gather issues for analysis from reviews.
	PMC SP 2.2 Take Corrective Action	Corrective Action Plan. Interviews.	Determine and document the appropriate actions needed to address the identified issues.
	PMC SP 2.3 Manage Corrective Actions	Corrective Action Result. Interviews.	Monitor corrective actions and analyze the results.

Supplier Agreement Management (SAM)

- A Project Management PA at ML 2
- The purpose of Supplier Agreement Management (SAM) is to manage the acquisition of products and services from suppliers.
- The SAM process area involves the following activities:
  - Determining the type of acquisition
  - Selecting suppliers
  - Establishing and maintaining agreements with suppliers
  - Executing supplier agreements
  - Accepting delivery of acquired products
  - Ensuring successful transition of acquired products

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Measurement and Analysis (MA)

- A Support PA at ML 2
- The purpose of Measurement and Analysis (MA) is to develop and sustain a measurement capability used to support management information needs.

Measurement and Analysis (MA)

- The Measurement and Analysis process are involves the following:
  - Specifying objectives of measurement and analysis
  - Specifying measures, analysis techniques, and mechanism for data collection, data storage, reporting and feedback
  - Implementing the analysis techniques and mechanisms for data collection, data reporting and feedback
  - Providing objective results that can be used in making informed decisions and taking appropriate corrective action

Process and Product Quality Assurance (PPQA)

- A Support PA at ML 2

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

Process and Product Quality Assurance (PPQA)

- The PPQA process area involves:
  - Objectively evaluating performed processes and work products against the applicable process descriptions, standards, and procedures
  - Identifying and documenting noncompliance issues
  - Providing feedback to project staff and managers on the results of QA activities
  - Ensuring that noncompliance issues are addressed

Configuration Management (CM)

- A Support PA at ML 2

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

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Configuration Management (CM)

- The Configuration Management process are involves:
  - Identifying the configuration of selected work products that compose the baselines at given points in time
  - Controlling changes to configuration items
  - Building or providing specifications to build work products from the configuration management system
  - Maintaining the integrity of baselines
  - Providing accurate status and current configuration data to developers, end users, and customers

Process Areas Presented in the Staged Representation: Maturity Level 3

- Requirements Development (RD)
- Technical Solution (TS)
- Product Integration (PI)
- Verification (VER)
- Validation (VAL)
- Organizational Process Focus (OPF)
- Organizational Process Definition (OPD)
- Organizational Training (OT)
- Integrated Project Management (IPM)
- Risk Management (RSKM)
- Decision Analysis and Resolution (DAR)

Process Areas	Category	ML
Requirements Management (REQM)	Project Management	2
Project Planning (PP)	Project Management	2
Project Monitoring and Control (PMC)	Project Management	2
Supplier Agreement Management (SAM)	Project Management	2
Measurement and Analysis (MA)	Support	2
Process and Product Quality Assurance (PPQA)	Support	2
Configuration Management (CM)	Support	2
Requirements Development (RD)	**Engineering**	**3**
Technical Solution (TS)	**Engineering**	**3**
Product Integration (PI)	**Engineering**	**3**
Verification (VER)	**Engineering**	**3**
Validation (VAL)	**Engineering**	**3**
Organizational Process Focus (OPF)	**Process**	**3**
Organizational Process Definition (OPD)	**Process**	**3**
Organizational Training (OT)	**Process**	**3**
Integrated Project Management (IPM)	**Project**	**3**
Risk Management (RSKM)	**Project**	**3**
Decision Analysis and Resolution (DAR)	**Support**	**3**
Organizational Process Performance (OPP)	Process Management	4
Quantitative Project Management (QPM)	Project Management	4
Organizational Performance Management (OPM)	Process Management	5
Causal Analysis and Resolution (CAR)	Support	5

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Process Areas Presented in the Staged Representation: Maturity Level 3

To achieve maturity level 3, all process areas assigned to maturity level 2 and 3 must achieve capability level 3.

Name	Abbr	ML	CL1	CL2	CL3
Requirement Management	REQM	2	Target Profile 2		
Project Planning	PP	2			
Project Monitoring and Control	PMC	2			
Supplier Agreement Management	SAM	2			
Measurement and Analysis	MA	2			
Process and Product Quality Assurance	PPQA	2			
Configuration Management	CM	2			
Requirements Development	RD	3	Target Profile 3		
Technical Solution	TS	3			
Product Integration	PI	3			
Verification	VER	3			
Validation	VAL	3			
Organizational Process Focus	OPF	3			
Organizational Process Definition + IPPD	OPD	3			
Organizational Training	OT	3			
Integrated Project Management + IPPD	IPM	3			
Risk Management	RSKM	3			
Decision Analysis and Resolution	DAR	3			
Organizational Process Performance	OPP	4	Target Profile 4		
Quantitative Project Management	QPM	4			
Organizational Performance Management	OPM	5	Target Profile 5		
Causal Analysis and Resolution	CAR	5			

Requirements Development (RD)

- An Engineering PA at Maturity Level 3
- The purpose of Requirements Development (RD) is to elicit, analyze, and establish customer, product, and product component requirements.
- RD describes three types of requirements:
  - Customer requirements
  - Product requirements
  - Product component requirements

Technical Solution (TS)

- An Engineering PA at ML 3
- The purpose of Technical Solution (TS) is to select, design, and implement solutions to requirements.
- This process area focuses on the following:
  - Evaluating and selecting solutions (referred to as "design approaches," "design concepts," or "preliminary designs")
  - Developing detailed designs for the selected solutions (detailed in the context of containing all the information needed to manufacture, code)
  - Implementing the designs as a product or product component

Product Integration (PI)

- An Engineering PA at ML 3

- The purpose of Product Integration (PI) is to assemble the product from the product components, ensure that the product, as integrated, behaves properly (i.e., possesses the required functionality and quality attributes), and deliver the product.

Verification (VER)

- An Engineering PA at ML 3
- The purpose of Verification (VER) is to ensure that selected work products meet their specified requirements.
- The VER PA involves the following:
  - Verification preparation
  - Verification performance
  - Identification of corrective action
- Verification includes verification of the product and intermediate work products against all selected requirements, including customer, product, and product components requirements.

Validation (VAL)

- An Engineering PA at ML 3
- The purpose of Validation (VAL) is to demonstrate that a product or product component fulfills its intended use when placed in its intended environment.
- Validation activities can be applied to all aspects of the product in any of its intended environments, such as operation, training, manufacturing, maintenance, and support services.
- Validation demonstrates that the product, as provided, will fulfill its intended use, whereas verification addresses whether the work product properly reflects the specified requirements.

Organizational Process Focus (OPF)

- A Process Management PA at ML 3

- The purpose of Organizational Process Focus (OPF) is to plan, implement, and deploy organizational process improvements based on a thorough understanding of the current strengths and weakness of the organization's processes and process assets.

Organizational Process Definition (OPD)

- A Process Management PA in ML 3

- The purpose of Organizational Process Definition (OPD) is to establish and maintain a usable set of organizational process assets and work environment standards, and rules and guidelines for teams.

Organizational Training (OT)

- A Process Management PA at ML 3
- The purpose of Organizational Training (OT) is to develop the skills and knowledge of people so they can perform their roles effectively and efficiently.
  - Identifying the training needed by the organization
  - Obtaining and providing training to address those needs
  - Establishing and maintaining training capability
  - Establishing and maintaining training records
  - Assessing training effectiveness

Integrated Project Management (IPM)

- A Project Management PA at ML 3

- The purpose of Integrated Project Management (IPM) 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.

Risk Management (RSKM)

- A Project Management PA at ML 3
- The purpose of Risk Management (RSKM) is to identify potential problems before they occur so that risk-handling activities can be planned and invoked as needed across the life of the product or project to mitigate adverse impacts on achieving objectives.
- RSKM can be divided into three parts:
  - Defining a risk management strategy
  - Identifying and analyzing risks
  - Handling identified risks, including the implementation of risk mitigation plans (and contingency plan) when needed

Decision Analysis and Resolution (DAR)

- A Support PA at ML 3

- The purpose of Decision Analysis and Resolution (DAR) is to analyze possible decisions using a formal evaluation process that evaluates identified alternatives against established criteria.

- A formal evaluation process is a structured approach to evaluating alternative solution against established criteria to determine a recommended solution.

Process Areas Presented in the Staged Representation: Maturity Level 4

- Organizational Process Performance (OPP)

- Quantitative Project Management (QPM)

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Process Areas	Category	ML
Requirements Management (REQM)	Project Management	2
Project Planning (PP)	Project Management	2
Project Monitoring and Control (PMC)	Project Management	2
Supplier Agreement Management (SAM)	Project Management	2
Measurement and Analysis (MA)	Support	2
Process and Product Quality Assurance (PPQA)	Support	2
Configuration Management (CM)	Support	2
Requirements Development (RD)	Engineering	3
Technical Solution (TS)	Engineering	3
Product Integration (PI)	Engineering	3
Verification (VER)	Engineering	3
Validation (VAL)	Engineering	3
Organizational Process Focus (OPF)	Process Management	3
Organizational Process Definition (OPD)	Process Management	3
Organizational Training (OT)	Process Management	3
Integrated Project Management (IPM)	Project Management	3
Risk Management (RSKM)	Project Management	3
Decision Analysis and Resolution (DAR)	Support	3
Organizational Process Performance (OPP)	**Process**	**4**
Quantitative Project Management (QPM)	**Project**	**4**
Organizational Performance Management (OPM)	Process Management	5
Causal Analysis and Resolution (CAR)	Support	5

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Process Areas Presented in the Staged Representation: Maturity Level 4

To achieve maturity level 4, all process areas assigned to maturity levels 2, 3, and 4 must achieve capability level 3.

Name	Abbr	ML	CL1	CL2	CL3
Requirement Management	REQM	2			
Project Planning	PP	2			
Project Monitoring and Control	PMC	2		Target Profile 2	
Supplier Agreement Management	SAM	2			
Measurement and Analysis	MA	2			
Process and Product Quality Assurance	PPQA	2			
Configuration Management	CM	2			
Requirements Development	RD	3			
Technical Solution	TS	3			
Product Integration	PI	3			
Verification	VER	3			
Validation	VAL	3			
Organizational Process Focus	OPF	3			
Organizational Process Definition + IPPD	OPD	3			
Organizational Training	OT	3		Target Profile 3	
Integrated Project Management + IPPD	IPM	3			
Risk Management	RSKM	3			
Decision Analysis and Resolution	DAR	3			
Organizational Process Performance	OPP	4		Target Profile 4	
Quantitative Project Management	QPM	4			
Organizational Performance Management	OPM	5		Target Profile 5	
Causal Analysis and Resolution	CAR	5			

Organizational Process Performance (OPP)

- A Process Management PA at ML 4

- The purpose of Organizational Process Performance (OPP) is to establish and maintain a quantitative understanding of the performance of selected processes in the organization's set of standard processes in support of achieving quality and process performance objectives, and to provide process performance data, baselines, and models to quantitatively manage the organization's projects.

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Quantitative Project Management (QPM)

- A Project Management PA at ML 4

- The purpose of Quantitative Project Management (QPM) is to quantitatively manage the project to achieve the project's established quality and process performance objectives.

Quantitative Project Management (QPM)

- The QPM PA involves the following activities:
  - Establishing and maintaining the project's quality and process performance objectives
  - Composing a defined process for the project to help to achieve the project's quality and process performance objectives
  - Selecting subprocesses and attributes critical to understanding performance and that help to achieve the project's quality and process performance objectives
  - Selecting measures and analytic techniques to be used in quantitative management

Quantitative Project Management (QPM)

- The QPM PA involves the following activities:
  - Monitoring the performance of selected subprocesses using statistical and other quantitative techniques
  - Managing the project using statistical and other quantitative techniques to determine whether or not the project's objectives for quality and process performance are being satisfied
  - Performing root cause analysis of selected issues to address deficiencies in achieving the project's quality and process performance objectives

Process Areas Presented in the Staged Representation Maturity: Level 5

- Organizational Performance Management (OPM)

- Causal Analysis and Resolution (CAR)

Process Areas	Category	ML
Requirements Management (REQM)	Project Management	2
Project Planning (PP)	Project Management	2
Project Monitoring and Control (PMC)	Project Management	2
Supplier Agreement Management (SAM)	Project Management	2
Measurement and Analysis (MA)	Support	2
Process and Product Quality Assurance (PPQA)	Support	2
Configuration Management (CM)	Support	2
Requirements Development (RD)	Engineering	3
Technical Solution (TS)	Engineering	3
Product Integration (PI)	Engineering	3
Verification (VER)	Engineering	3
Validation (VAL)	Engineering	3
Organizational Process Focus (OPF)	Process Management	3
Organizational Process Definition (OPD)	Process Management	3
Organizational Training (OT)	Process Management	3
Integrated Project Management (IPM)	Project Management	3
Risk Management (RSKM)	Project Management	3
Decision Analysis and Resolution (DAR)	Support	3
Organizational Process Performance (OPP)	Process Management	4
Quantitative Project Management (QPM)	Project Management	4
Organizational Performance Management	Process	5
Causal Analysis and Resolution (CAR)	Support	5

Process Areas Presented in the Staged Representation Maturity: Level 5

To achieve maturity level 5, all process areas must achieve capability level 3.

Name	Abbr	ML	CL1	CL2	CL3
Requirement Management	REQM	2			
Project Planning	PP	2			
Project Monitoring and Control	PMC	2		Target Profile 2	
Supplier Agreement Management	SAM	2			
Measurement and Analysis	MA	2			
Process and Product Quality Assurance	PPQA	2			
Configuration Management	CM	2			
Requirements Development	RD	3			
Technical Solution	TS	3			
Product Integration	PI	3			
Verification	VER	3			
Validation	VAL	3			
Organizational Process Focus	OPF	3			
Organizational Process Definition + IPPD	OPD	3			
Organizational Training	OT	3			
Integrated Project Management + IPPD	IPM	3			
Risk Management	RSKM	3		Target Profile 3	
Decision Analysis and Resolution	DAR	3			
Organizational Process Performance	OPP	4		Target Profile 4	
Quantitative Project Management	QPM	4			
Organizational Performance Management	OPM	5		Target Profile 5	
Causal Analysis and Resolution	CAR	5			

Organizational Performance Management (OPM)

- A Process Management PA at ML 5

- The purpose of Organizational Performance Management (OPM) is to proactively manage the organization's performance to meet its business objectives.

- The OPM PA enables the organization to manage organizational performance by iteratively analyzing aggregated project data, identifying gaps in performance against the business objectives, and selecting and deploying improvements to close the gaps.

Organizational Performance Management (OPM)

- Business objectives that this process area might address include the following:
  - Improved product quality (e.g., functionality, quality attributes)
  - Increased productivity
  - Increased process efficiency and effectiveness
  - Increased consistency in meeting budget and schedule
  - Decreased cycle time
  - Greater customer and end-user satisfaction
  - Shorter development or production time to change functionality, add new features, or adapt to new technologies
  - Improved performance of a supply chain involving multiple suppliers
  - Improved use of resources across the organization

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Causal Analysis and Resolution (CAR)

- A Support PA at ML 5
- The purpose of Causal Analysis and Resolution (CAR) is to identify causes of selected outcomes and take action to improve process performance.

Causal Analysis and Resolution (CAR)

- The CAR PA involves the following:
  - Identifying and analyzing causes of selected outcomes (e.g., defects and other problems).
  - Taking specific actions to complete the following:
    - Remove the causes and prevent the occurrence of those types of defects and problems in the future.
    - Proactively analyze data to identify potential problems and prevent them from occurring.
    - Incorporate the causes of successes into the process to improve future process performance.

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Glossary

- The basic terms used in the CMMI models

Glossary

- The CMMI glossary defines the basic terms used in the CMMI models.

- The CMMI glossary of terms is <u>not</u> a required, expected, or informative component of CMMI models.

Glossary

- Examples:
- Informative CMMI components
  - CMMI components that help model users understand the required and expected components of a model.
  - These components can contain examples, detailed explanations, or other helpful information.
    - Sub-practices, notes, references, goal titles, practice titles, sources, typical work products, amplifications (information relevant to a particular discipline), and generic practice elaborations

Glossary

- Examples:

- Institutionalization

  - The ingrained way of doing business that an organization follows routinely as part of its corporate culture.

- ...

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