

CMMI: What do we need to do in Requirements Management & Engineering?

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1 Abstract

To achieve CMMI level 2 or higher an organisation needs amongst other things Requirements Management and Engineering process capability. How can this be achieved?

Here the proposals of CMMI for Requirements Management and Engineering (RM&E) are investigated using RM&E techniques. CMMI provides the aims and we suggest how these aims may be fulfilled.

As in all good systems investigations, the Problem Domain (User Requirements) is separated from the Solution Domain (System Requirements and Design). CMMI provide the User Requirements and we investigate the Systems Requirements. CMMI states the aims and we investigate solutions.

The first stage is to recognise from the CMMI specification which parts can in fact be regarded as Requirements.

2 Aim

The aims of this document are to introduce the reader to CMMI and to show the reader a little of what is needed to achieve conformance to CMMI for Requirements Management and Engineering process capabilities.

3 Structure of Document

After the Abstract in Chapter 1, and the Aim in Chapter 2, the structure of the document is explained here in chapter 3. The Background to CMM and CMMI is given in Chapter 4, explaining where CMM came from and how it may be used. From the CMMI specification the requirements to be fulfilled are extracted and summarised in Chapter 5. Having defined the criteria for success (“Success is fulfilment of Requirements” Colin Hood) Chapter 6 details what might be done to achieve the different levels of fulfilment.

Conclusions are drawn in Chapter 7. Trademarks and Service Marks are acknowledged in Chapter 8.

4 Background

The Capability Maturity Model (CMM) was developed by the Software Engineering Institute of Carnegie Mellon University on behalf of the U.S. Department of Defense.

Although originally intended as a means of assessing an organizations capability in Software Development, since 1992 the Author has used CMM to encourage organisations to measurably improve processes and organisational capabilities in a variety of fields.

Since 1991, CMMs have been developed for a myriad of disciplines. Some of the most notable include models for systems engineering, software engineering, software acquisition, workforce management and development, and Integrated Product and Process Development.

Organizations from industry, government, and the Software Engineering Institute (SEI) joined together to develop the CMMI Framework, a set of integrated CMMI models, a CMMI appraisal method, and supporting products. These organizations donated the time of one or more of their people to participate in the CMMI project.

5 CMMI Requirements

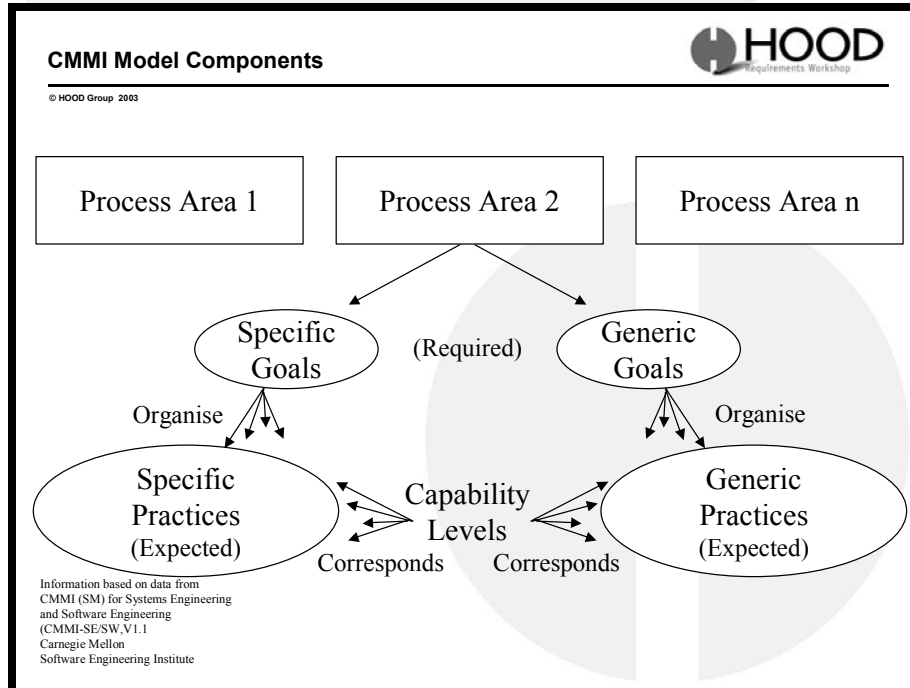
5.1 Introduction

Capability Maturity Model Integration (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 not map one to one with the processes used in your organization.

5.2 Structure of CMMI

The Structure of CMMI is described by listing the representation of the CMMI components and showing the relationship between Capability Levels, Process Areas, and Goals and Practices.



Process Areas contain Goals, which organise Practices. The Practices correspond to Capability Levels.

The specific goals organize specific practices and the generic goals organize generic practices. Each specific and generic practice corresponds to a capability level. Specific goals and specific practices apply to individual process areas. Generic goals and generic practices apply to multiple process areas. The generic goals and generic practices define a sequence of capability levels that represent improvements in the implementation and effectiveness of all the processes you choose to improve.

Both Specific and Generic Goals are required Components of CMMI. These components must be achieved by an organization's planned and implemented processes. Required components are essential to rating the achievement of a process area. Goal achievement (or satisfaction) is used in appraisals as the basis upon which process area satisfaction and organizational maturity are determined.

Specific and Generic Practices are expected Components of CMMI. Expected components describe what an organization will typically implement to achieve a required component. Expected components guide those implementing improvements or performing appraisals. Either the practices as described, or acceptable alternatives to them, are expected to be

present in the planned and implemented processes of the organization before goals can be considered satisfied.

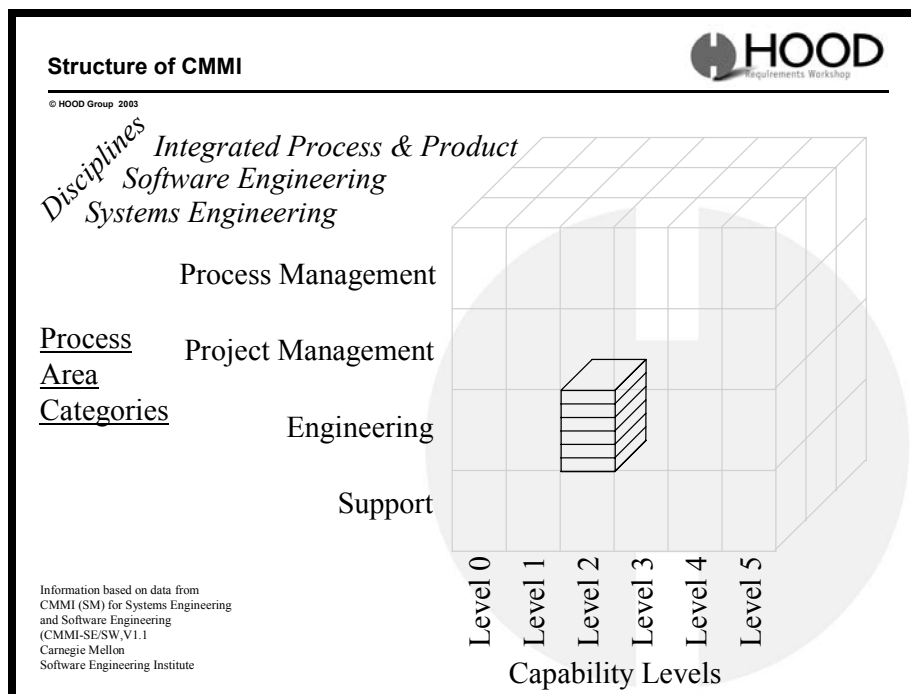
A capability level consists of related specific and generic practices for a process area that can improve the organization's processes associated with that process area. As you satisfy the generic and specific goals for a process area at a particular capability level, and you achieve that capability level, you reap the benefits of process improvement.

Capability levels focus on growing the organization's ability to perform, control, and improve its performance in a process area. Capability levels enable you to track, evaluate, and demonstrate your organization's progress as you improve processes associated with a process area. Capability levels build on each other, providing a recommended order for approaching process improvement.

There are six capability levels, designated by the numbers 0 through 5:

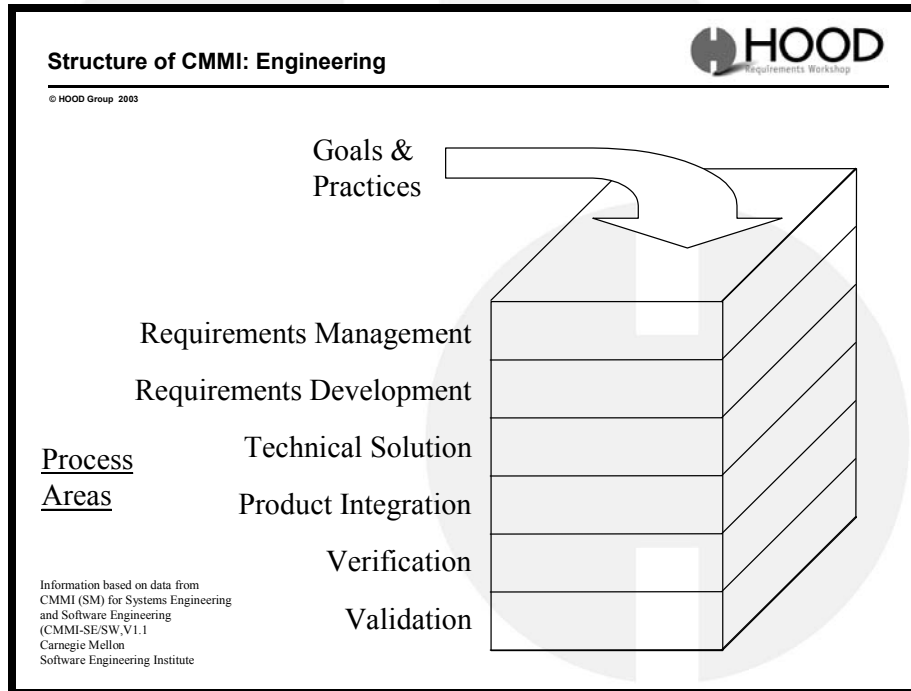
- 0. Incomplete
- 1. Performed
- 2. Managed
- 3. Defined
- 4. Quantitatively Managed
- 5. Optimizing

We will concentrate on level 2 for demonstration purposes.



Process Area Categories group Process Areas together. For the disciplines of *Systems Engineering* and for *Software Engineering* the Process Area Categories of “Process Management”, “Project Management”, “Engineering”, and “Support” are used. In this paper

we concentrate on **Requirements Management** and **Requirements Development** which are to be found within the Process Area Category “Engineering”.



Within the Process Area Category of “Engineering” the Process Areas; **Requirements Management**, **Requirements Development**, **Technical Solution**, **Product Integration**, **Verification**, and **Validation** are listed. We are interested in the Specific Goals and Specific Practices for the Process Areas **Requirements Management**, and **Requirements Development**.

5.3 Requirements: Required and Expected Model Elements

5.3.1 Problem and Solution Domains

Here we consider the CMMI Required Model Elements to be requirements. These requirements give aims to be fulfilled. The aims do not describe a solution, and are therefore considered to be outside of the requirements solution domain. The aims are in a domain sometimes referred to as Problem Domain and the requirements are sometimes referred to as User Requirements or Stakeholder Requirements or Customer Requirements.

In contrast to Required Model Elements, the Expected Model Elements are considered to be in the Solution Domain. The Expected Model Elements describe one of many possible Abstract Solutions, which must be implemented by a process in your organisation.

5.3.2 Introduction to Required and Expected Model Elements

From the Process Areas of Process Management, Project Management, Engineering, and Support, this paper concentrates on the area of Engineering. Within the Process Area of Engineering CMMI lists; Requirements Management, Requirements Development, Technical

Solution, Product Integration, Verification, and Validation, of which Requirements Management and Requirements Development are investigated here.

The Goals stated in CMMI (both Generic and Specific) are required to be fulfilled. The Practices suggested here are guides to help you fulfil the required Goals. Other Practices may be, and are expected to be, used. CMMI states “Expected components describe what an organization will typically implement to achieve a required component. Expected components guide those implementing improvements or performing appraisals. Either the practices as described, or acceptable alternatives to them, are expected to be present in the planned and implemented processes of the organization before goals can be considered satisfied.”

This chapter uses Specific Goals and Specific Practices as examples. The Generic Goals and Generic Practices, which are dependent on the Capability Level, are not listed here due to space constraints. Both Generic and Specific may be treated in a similar way.

Each capability level (1-5) has only one generic goal that describes the institutionalization that the organization must achieve at that capability level. Thus, there are five generic goals; each appears in every process area. Achievement of a generic goal in a process area signifies improved control in planning and implementing the processes associated with that process area thus indicating whether these processes are likely to be effective, repeatable, and lasting. Generic goals are required model components and are used in appraisals to determine whether a process area is satisfied.

5.3.3 Requirements Management

In the following sub-chapters the Specific Goal (SG) is listed along with the relevant expected Specific Practices (SP).

The purpose of Requirements Management is to manage the requirements of the project's products and product components and to identify inconsistencies between those requirements and the project's plans and work products.

5.3.3.1 SG 1 Manage Requirements

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

5.3.3.1.1 SP 1.1-1 Obtain an Understanding of Requirements

Develop an understanding with the requirements providers on the meaning of the requirements.

5.3.3.1.2 SP 1.2-2 Obtain Commitment to Requirements

Obtain commitment to the requirements from the project participants.

5.3.3.1.3 SP 1.3-1 Manage Requirements Changes

Manage changes to the requirements as they evolve during the project.

5.3.3.1.4 SP 1.4-2 Maintain Bidirectional Traceability of Requirements

Maintain bidirectional traceability among the requirements and the project plans and work products.

5.3.3.1.5 SP 1.5-1 Identify Inconsistencies between Project Work and Requirements

Identify inconsistencies between the project plans and work products and the requirements.

5.3.4 Requirements Development

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

In the following sub-chapters the Specific Goals are listed along with the relevant expected Specific Practices

5.3.4.1 SG 1 Develop Customer Requirements

Stakeholder needs, expectations, constraints, and interfaces are collected and translated into customer requirements.

5.3.4.1.1 SP 1.1-1 Collect Stakeholder Needs

Identify and collect stakeholder needs, expectations, constraints, and interfaces for all phases of the product life cycle.

5.3.4.1.2 SP 1.1-2 Elicit Needs

Elicit stakeholder needs, expectations, constraints, and interfaces for all phases of the product life cycle

5.3.4.1.3 SP 1.2-1 Develop the Customer Requirements

Transform stakeholder needs, expectations, constraints, and interfaces into customer requirements

5.3.4.2 SG 2 Develop Product Requirements

Customer requirements are refined and elaborated to develop product and product-component requirements.

5.3.4.2.1 SP 2.1-1 Establish Product and Product-Component Requirements

Establish and maintain product and product-component requirements, which are based on the customer requirements.

5.3.4.2.2 SP 2.2-1 Allocate Product-Component Requirements

Allocate the requirements for each product component.

5.3.4.2.3 SP 2.3-1 Identify Interface Requirements

Identify interface requirements.

5.3.4.3 SG 3 Analyze and Validate Requirements

The requirements are analyzed and validated, and a definition of required functionality is developed. [

5.3.4.3.1 SP 3.1-1 Establish Operational Concepts and Scenarios

Establish and maintain operational concepts and associated scenarios. [

5.3.4.3.2 SP 3.2-1 Establish a Definition of Required Functionality

Establish and maintain a definition of required functionality.

5.3.4.3.3 SP 3.3-1 Analyze Requirements

Analyze requirements to ensure that they are necessary and sufficient. [

5.3.4.3.4 SP 3.4-3 Analyze Requirements to Achieve Balance

Analyze requirements to balance stakeholder needs and constraints. [

5.3.4.3.5 SP 3.5-1 Validate Requirements

Validate requirements to ensure the resulting product will perform appropriately in its intended-use environment.

5.3.4.3.6 SP 3.5-2 Validate Requirements with Comprehensive Methods

Validate requirements to ensure the resulting product will perform as intended in the user's environment using multiple techniques as appropriate.

6 Fulfilling Requirements

6.1 Introduction to Fulfilling Requirements

Before you begin using a CMMI model for improving processes, you must map your processes to CMMI process areas. This mapping enables you to control process improvement in your organization by helping you track your organization's level of conformance to the CMMI model you are using. It is not intended that every CMMI process area maps one to one with your organization's processes.

6.2 Example Requirements

For a Requirements Management process for instance we can see that CMMI requires the following Specific Goal to be achieved;

- SG 1 Manage Requirements (Requirements are managed and inconsistencies with project plans and work products are identified)

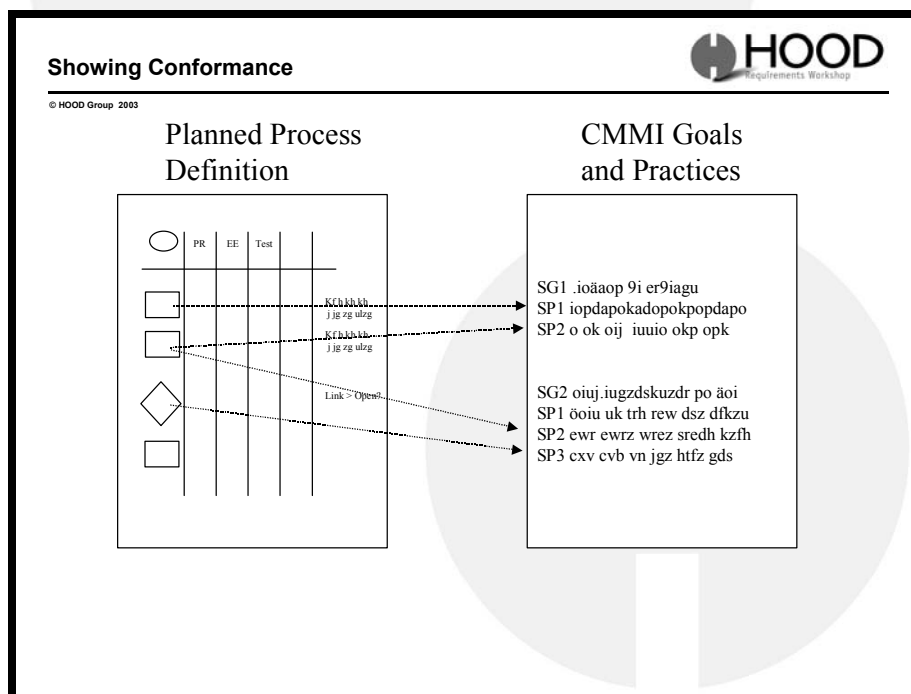
For Requirements Development process we see that CMMI requires the following Specific Goals to be achieved;

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

- SG 2 Develop Product Requirements (Customer requirements are refined and elaborated to develop product and product-component requirements.)
- SG 3 Analyze and Validate Requirements (The requirements are analyzed and validated, and a definition of required functionality is developed)

6.3 Showing Conformance

To achieve conformance to CMMI it is suggested that processes be developed and linked to the relevant parts of CMMI. In this way conformance is easily shown, and improvements can be managed in an orderly manner.



The CMMI states, “When you use a CMMI model as a guide, you plan and implement processes that conform to the required and expected components of process areas. Conformance with a process area means that in the planned and implemented processes there is an associated process (or processes) that addresses either the specific and generic practices of the process area or alternatives that clearly and unequivocally accomplish a result that meets the goal associated with that specific or generic practice.”

6.4 An incomplete Example of Linking CMMI Goals and Practices to Organisational activities from a Planned Process.

Problem Domain		Solution Domain	
Generic Goal	Specific Goal	Specific and General Practice	Example Implementation
Level 2 Generic Goals GG 2 Institutionalize a Managed Process The process is institutionalized as a managed process	SG 1 Manage Requirements Requirements are managed and inconsistencies with project plans and work products are identified.	<i>SP 1.1-1 Obtain an Understanding of Requirements</i> Develop an understanding with the requirements providers on the meaning of the requirements.	At a Requirements Elicitation Workshop all attendees will discuss, model, and document requirements to develop an understanding of the requirements The commitment to the requirements documented at the workshop will be obtained and documented through acceptance of the requirements at reviews during the workshop.
		<i>SP 1.2-2 Obtain Commitment to Requirements</i> Obtain commitment to the requirements from the project participants.	
		<i>Level 2 Generic Practices GP 2.1 Establish an Organizational Policy</i> Establish and maintain an organizational policy for planning and performing the process.	The Project Member responsible for Requirements Elicitation must Invite by all parties to the Requirements Elicitation Workshops (Roles, responsibilities, and Stakeholders are detailed in the list of Stakeholders for your project.) Invitations must be sent between 2 and 4 weeks before the planned start of the workshop. Include with the invitation to the workshop a link to where all information is to be found on the Intranet. The Workshop may only be led by a person with a grade xyz qualification.

As the level of capability increases, different Generic Goals will be satisfied.

7 Conclusion

CMMI is supportive of Process Improvement. CMMI does not prescribe how work has to be done, but it does define what has to be achieved to reach defined levels of maturity.

Goals are set that must be achieved. Practices are suggested that are expected to be found, but may be replaced with other practices. This allows much freedom of implementation and makes CMMI applicable and useful over a wide range of applications.

To achieve conformance to CMMI it is suggested that processes be developed and linked to the relevant parts of CMMI. In this way conformance is easily shown, and improvements can be managed in an orderly manner.

8 Trademarks and Service Marks

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