The CMMI in 45 Minutes

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Notes:

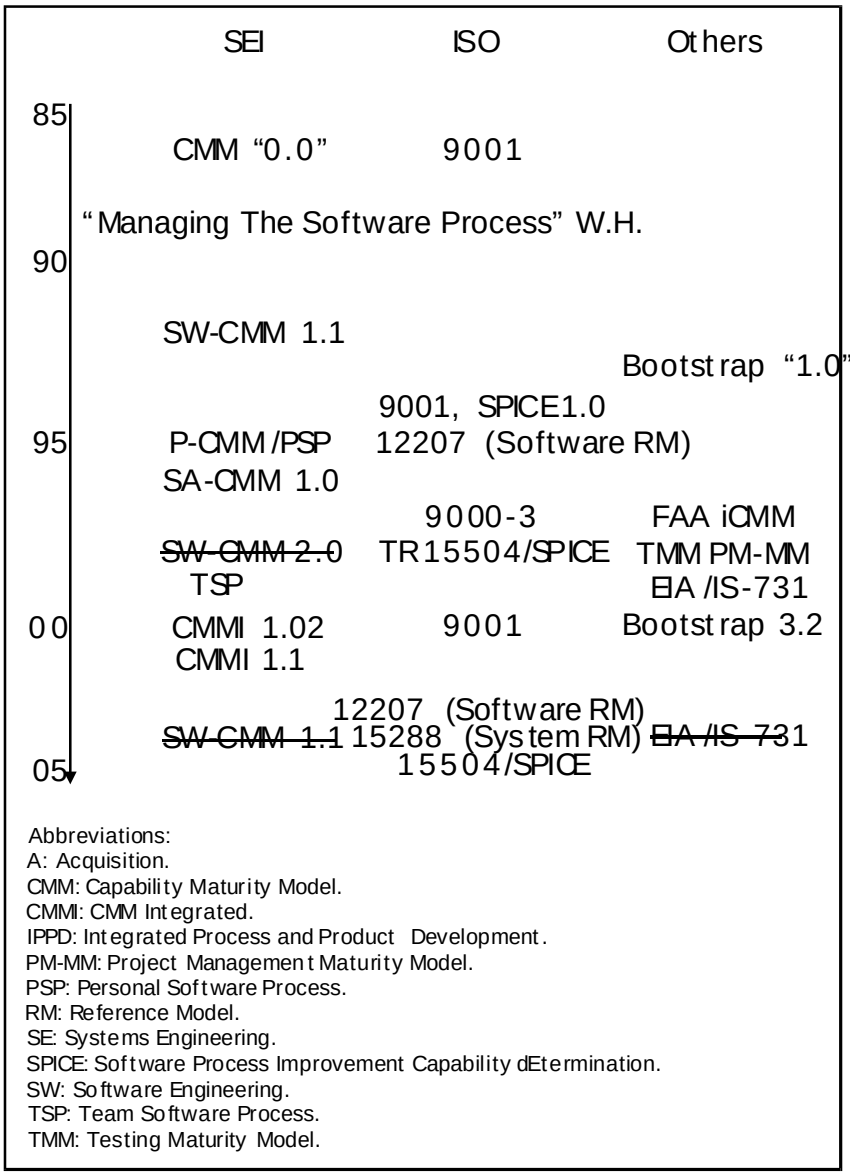
1. If you are not familiar with the CMM please get general information about this model from the SEI publications at [1].
2. This document is based on version 1.02 of the CMMI-SE/SW, the core of the CMMI model. Other versions such as the CMMI-SE/SW/IPPD and CMMI-SE/SW/IPPD/SS add some Process Areas, the concepts covered in this document, however, are also valid for those variants.
3. Version 1.1 of the CMMI standard is currently pending for release. The information given by the SEI so far indicates that no major changes are to be expected.
4. ISO TR 15504 is currently not an ISO standard, but a technical report.
5. Capability Maturity Model and CMM are registered in the U.S. Patent and Trademark Office.
6. CMMI, CMM Integration, PSP, SCAMPI, and TSP are service marks of Carnegie Mellon University.

1 Introduction

With the release of the Capability Maturity Model-Integrated (CMMI) the Software Engineering Institute puts a preliminary end to a journey started in the mid-nineties: After the release of the CMM v1.1 (Software-CMM) in 1993 the efforts to issue version 2.0 were abandoned in favour of a general purpose Capability Maturity Model that would integrate several disciplines.

The intention of this effort is to address not only Software Engineering, but also System Engineering, Integrated Process and Product Development, and other disciplines like Acquisition and Supplier Sourcing. This made sense for the reason that an ongoing diversification of discipline-specific CMMs would have caused more harm than good, due to possible redundancies and the likely need to use multiple CMMs in one organization. A timeline diagram of the releases and sunsets of quality publications and standards by the SEI, the ISO, and others is given in diagram 1.

Diagram 1: Important Software Quality Standards and Models between 1985 and 2005.



This paper serves as a concise description of the architecture, major parts and features of the CMMI.

2 Which Model to choose?

The CMMI is integrated in the sense that it is made up of a core that is extended as disciplines are added. The core model is the CMMI-SE/SW (Systems Engineering and Software Engineering). The extended models in the making so far are the CMMI-SE/SW/IPPD (Integrated Product and Process Development) and the CMMI-SE/SW/IPPD/SS (Supplier Sourcing, formerly Acquisition).Table 1 outlines the intended usage of the respective models.

Table 1: The CMMI models.

CMMI Model	Target Organization Type
SE/SW	Software/System Engineering
SE/SW/IPPD	Software/System Engineering with focus on early, continuing stakeholder involvement.
SE/SW/IPPD/SS	Software/System Engineering with focus on early, continuing stakeholder involvement and supplier sourcing.

3 The overall structure: One Model, two Representations

At least two goals were clear beyond the need for integration at the very beginning of the CMMI development:

1. The staged maturity levels prevented the CMM from delivering the flexibility needed in many organizations that have to adjust their process improvement to their business goals and not vice versa.
2. The transition of organizations that used the CMM v1.1 in the past to the CMMI should be as easy as possible to protect the considerable investments made so far.

The solution to those challenges was one model and two representations: **staged** and **continuous**.
The continuous representation is clearly more flexible in that it allows for a much more fine grained improvement strategy that aligns with the overall goals of the respective organization. It should also be noted that the continuous representation is likely to be more compatible to ISO 15504 / SPICE type assessments.
The staged model in contrast is the preferred model for organizations that want to migrate from CMM v1.1 to the CMMI with minimum overhead.

Each of the two representations comes as a document of seven chapters and around six hundred pages. They are available for download at the SEI web-site at [2].

4 The representation differences: Maturity vs. Capability

It should be noted that the two representations have to a very large degree the same content: They have exactly the same 22 Process Areas (PAs), the generic and specific goals are close to congruent, and the so called equivalent staging allows the unidirectional translation of assessment results from the continuous to the staged representation.

A major difference exists at the top level of the representations: In the staged representation we still have the **Maturity Levels (MLs)** as they are found in CMM v1.1 and the Process Areas are assigned to the upper four of the five Maturity Levels (Managed, Defined, Quantitatively Managed, Optimizing).

In the continuous representation, however**,** Maturity Levels are replaced by **Capability Levels (CLs)** as a measure assigned individually to each Process Area. The following table 2 shows the existing maturity or capability levels of each representation, the old CMM v1.1 Maturity Levels and ISO TR 15504 (also known as SPICE). From this table the similarities between the staged model and the SW-CMM as well as the ones between the continuous representation and ISO 15504 can be identified.

Table 2: Maturity and Capability Levels of CMM, CMMI, and ISO 15504 models

Representation: Level:	CMMI Staged Maturity	CMMI Continuous Capability	CMM v1.1 (1993) Maturity	ISO 15504 Capability
5	Optimizing	Optimizing	Optimizing	Optimizing
4	Quantit. Managed	Quantit. Managed	Managed	Predictable
3	Defined	Defined	Defined	Established
2	Managed	Managed	Repeatable	Managed
1	Initial	Performed	Initial	Performed
0	-	Incomplete	-	Incomplete

5 The details: Process Areas, Goals, Practices, and Work Products

It has been stated that in both representations there are 22 Process Areas existing, compared to 18 in the CMM v1.1. However, in the continuous representation Process Areas are grouped according to four so called Process Area Categories (PAC). Those categories are listed in Table 3. For the purpose of easy comparison the process categories of ISO 15504 are also listed.

Table 3: CMMI Process Area Categories and ISO 15504 Process Categories

CMMI Process Area Categories Continuous	ISO 15504 Process Categories
Process Management	Organization
Project Management	Management
Engineering	Engineering
Support	Support
	Customer-Supplier

The mapping of process areas between Maturity Levels in the staged representation and Process Area Categories in the continuous representation is presented in matrix 1.

Matrix 1: Mapping from Maturity Levels to Process Area Categories (PACs)

Continuous

Staged

PAC Maturity	Process Managem.	Project Managem.	Engine-ering	Support
5	OID CL0-5			CAR CL0-5
4	OPP CL0-5	QPMCL0-5		
3	OPD CL0-5 OT CL0-5 OPF CL0-5	RSKM CL0-5 IPM CL0-5	PI CL0-5 RD CL0-5 TS CL0-5 VER CL0-5 VAL CL0-5	DAR CL0-5
2		PP CL0-5 SAM CL0-5 PMC CL0-5	REQM CL0-5	PPQA CL0-5 CM CL0-5 MA CL0-5
1				

Process Areas:

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

Each PA contains up to three Specific Goals (SG) and each of those goals comes with several Specific Practices (SP). The specific goals and practices are the operational trajectories of the standard and lead to typical work products that are also mentioned in the standard.
Something that can be explained best as generic quality improvement cycle is established with five Generic Goals and the accompanying 18 Generic Practices (GP). This leads to unnecessary redundancies that are a major cause of complaints on the standard in its current form. Table 4 is an example of the described hierarchy.

Table 4: The element hierarchy and example elements.

Model Element Name	Actual Name	Assessment Relevance	Comment
Representation (2)	Continuous	None	
Process Area Category (4)	Project Management	None	
Process Area (22)	Risk Management	None	
Generic Goal (5)	Achieve specific goals	Required	“Must have.”
Generic Practice (18)	Identify work scope	Expected	“Alternatives possible.”
Specific Goal (48)	Identify and analyze risks	Required	“Must have.”
Specific Practice (168)	Evaluate, categorize, prioritize risk.	Expected	“Alternatives possible.”
Typical Work Products	Rated list of risks	None/Informative	“Information only.”

In addition to those elements, at the bottom of the model we find

- subpractices,
- examples,
- elaborations, and
- discipline specific amplifications.

Albeit they are not target for assessments, they contain a wealth of practical process and engineering knowledge.

6 Capability Level Profiles

The fact that each Process Area has an individually assigned capability level in the continuous representation leads to a so called capability level profile: 22 capability levels from zero (incomplete) to five (optimising) assigned to the respective Process Areas. Matrix 2 gives an example:

Matrix 2: Capability Level Profile.

Continuous

Staged: PAC Maturity	Process Managem.	Project Managem.	Engine-ering	Support
5	OID CL 3			CAR CL 1
4	OPP CL 2	QPM CL 0		
3	OPD CL 1 OT CL 2 OPF CL 2	RSKM CL 2 IPM CL 1 3	PI CL 3 RD CL 4 TS CL 2 VER CL 2 VAL CL 3	DAR CL 3
2		PP CL 2 SAM CL 3 PMC CL 3	REQM CL 2	PPQA CL 3 CM CL 3 MA CL 2
1				

Equivalent Staging

There is a unidirectional mapping from the continuous to the staged representation. This is called equivalent staging. It sets the standards for what capability levels have to be achieved to be equivalent with a certain maturity level of the continuous representation. An example of the capability levels needed for level 2 equivalence is given in Matrix 3. The Maturity Level 3-5 PAs are not of interest for a Maturity Level 2 rating.

Matrix 3: Maturity Level 2 equivalent Capability Level Profile.

Continuous

Staged

PAC Maturity	Process Managem.	Project Managem.	Engine-ering	Support
5	OID			CAR
4	OPP	QPM		
3	OPD OT OPF	RSKM IPM	PI RD TS VER VAL	DAR
2		PP CL 2 SAM CL 2 PMC CL 2	REQM CL 2	PPQA CL 2 CM CL 2 MA CL 2
1				

An example of the capability levels needed for level 3 equivalence is given in matrix 4 (Maturity Level 4-5 PAs are not of interest).

Matrix 4: Maturity Level 3 equivalent Capability Level Profile

Continuous

Staged

PAC Maturity	Process Managem.	Project Managem.	Engine-ering	Support
5	OID			CAR
4	OPP	QPM		
3	OPD CL 3 OT CL 3 OPF CL 3	RSKM CL 3 IPM CL 3	PI CL 3 RD CL 3 TS CL 3 VER CL 3 VAL CL 3	DAR CL 3
2		PP CL 3 SAM CL 3 PMC CL 3	REQM CL 3	PPQA CL 3 CM CL 3 MA CL 3
1				

In order to achieve Maturity Level 4 or 5 equivalence, an organization needs to achieve at least capability level 3 in the respective maturity level PAs and the PAs below this maturity level.

7 How to get assessed: ARC and SCAMPI

The assessment type employed for the CMM so far was the CMM Based Appraisals for Internal Process Improvement (CBI-IPI). Together with the CMMI comes a new assessment methodology called Standard CMMI Appraisal Method for Process Improvement (SCAMPI) that fully covers the newly introduced Appraisal Requirements for CMMI (ARC).
In general it is not required to conduct a full blown SCAMPI assessment as long as no formal capability or maturity rating is desired. The ARC defines 3 types of assessments with large, medium, and minimum resource needs. They are shown in table 5.

Table 5: The 3 available assessment types.

Assessment Type	ISO 15504 compatible	Use of SCAMPI	Lead Assessor need	Team Size
Class A	X	Possible	X	5-11
Class B	-	In parts	-	2-7
Class C	-	In parts	-	2-3

8 Weaknesses

- Numbering scheme for Goals and Practices: Clearly one of the downsides of the CMMI is the numbering scheme for goals and practices in its current form. The goals of a process area are numbered “1 to n”. A specific goal of a process area therefore may have the label “SG 3” and a generic goal “GG 5”.The practices corresponding to a goal use the index of the related goal and another index “1 to m” numbering it as one of the practices of this respective goal. In addition specific practices have a capability rating indicated by a dash and the respective capability level. A specific practice therefore may have the label “SP 3.3-1” and a generic practice “GP 5.1”. A clearer approach would have been to either assign a running number for all specific goals (1-48) or a add a Process Area indication such as “MA-SG 1” or “RSKM-SG 3”. Another simplification would have been to assign a capability level indication only to advanced practices, for example “SP 2.1-3”, that are small fraction of the practices. “SP 2.2” would then implicitly mean “SP 2.2-1”.

- Two Representations: One can argue whether the use of two representations was the right choice. It is certainly a compromise to please two conflicting interests and the drawbacks are pretty clear: redundancies and inconsistencies. However, consensus and not single perspective, optimum solutions are the bottom line of most standardization projects.

- Redundancies: The repetition of the Generic Goals and Practices in each of the 22 PAs is in my opinion an unnecessary burden, that could be avoided by solely putting the elaborations in front of each process area description.

9 Strengths

One of the major criticism of the existing SW-CMM stems from the fact that it was targeted at large organizations such as defence contractors and had very little means for adaptation to the environments and goals of smaller companies or organizations. The CMMI is not an easy standard, however, it has become much more adaptable to varying needs.

- Capability Levels Specific to Process Area: Organizations using the continuous representations are free to tailor their improvement direction according to their specific business needs. They can now choose process area by process area where to focus improvement attention.

- Small Projects: It is now explicitly stated that the model can and should be adapted if applied to smaller projects, reducing the formal overhead imposed.

- Discipline Amplifications: As an integrated standard, the CMMI addresses several disciplines. To avoid the danger of becoming too general, some parts come with amplifications for specific disciplines.

- Three classes of Appraisals: In the past the considerable resource requirements for conducting assessments was a significant obstacle for doing them. With the newly introduced Class B and Class C assessment types the SEI gives the opportunity for conducting cost effective assessments in environments without the resources that large DoD contractors usually have.

10 References

[1]: SEI SW-CMM v1.1: http://www.sei.cmu.edu/cmm .
[2]: SEI CMMI: http://www.sei.cmu.edu/cmmi .
[3]: Ahern, D.; Clouse, A; Turner, R.: CMMI Distilled, Addison-Wesley, 2001.

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