**CAPABILITY MATURITY MODEL INTEGRATION (CMMI)**

**Capability Maturity Model Integration (CMMI)** is a successor of CMM and is a more evolved model that incorporates best components of individual disciplines of CMM like Software CMM, Systems Engineering CMM, People CMM, etc. Since CMM is a reference model of matured practices in a specific discipline, so it becomes difficult to integrate these disciplines as per the requirements. This is why CMMI is used as it allows the integration of multiple disciplines as and when needed.

**What is CMM?**

* CMM stands for **C**apability **M**aturity **M**odel.
* Focuses on elements of essential practices and processes from various bodies of knowledge.
* Describes common sense, efficient, proven ways of doing business (which you should already be doing) − not a radical new approach.
* CMM is a method to evaluate and measure the maturity of the software development process of an organization.
* CMM measures the maturity of the software development process on a scale of 1 to 5.
* CMM v1.0 was developed by the Software Engineering Institute (SEI) at Carnegie Mellon University in Pittsburgh, USA.
* CMM was originally developed for Software Development and Maintenance but later it was developed for −
  + Systems Engineering
  + Supplier Sourcing
  + Integrated Product and Process Development
  + People CMM
  + Software Acquisition

## CMM Examples

* People CMM − Develop, motivate and retain project talent.
* Software CMM − Enhance a software focused development and maintenance capability.

## What is Maturity?

Definitions vary but mature processes are generally thought to be −

* Well-defined,
* Repeatable,
* Measured,
* Analyzed,
* Improved, and
* Effective.

CMM helps to solve the maturity problem by defining a set of practices and providing a general framework for improving them. The focus of CMM is on identifying key process areas and the exemplary practices that may comprise a disciplined software process.

## Immature vs Mature Organization

An immature organization would have the following characteristics −

* Process improvised during project
* Approved processes being ignored
* Reactive, not proactive
* Unrealistic budget and schedule
* Quality sacrificed for schedule
* No objective measure of quality

In contrast, the characteristics of a mature organization are as follows −

* Inter-group communication and coordination
* Work accomplished according to plan
* Practices consistent with processes
* Processes updated as necessary
* Well-defined roles/responsibilities
* Management formally commits

## What is CMMI?

CMM Integration project was formed to sort out the problem of using multiple CMMs. CMMI product team's mission was to combine three **Source Models** into a single improvement framework for the organizations pursuing enterprise-wide process improvement. These three Source Models are −

* Capability Maturity Model for Software (SW-CMM) - v2.0 Draft C.
* Electronic Industries Alliance Interim Standard (EIA/IS) - 731 Systems Engineering.
* Integrated Product Development Capability Maturity Model (IPD-CMM) v0.98.

**CMM Integration**

* Builds an initial set of integrated models.
* Improves best practices from source models based on lessons learned.
* Establishes a framework to enable integration of future models.

## Difference between CMM and CMMI

CMM is a reference model of matured practices in a specified discipline like Systems Engineering CMM, Software CMM, People CMM, Software Acquisition CMM etc., but they were difficult to integrate as and when needed.

CMMI is the successor of the CMM and evolved as a more matured set of guidelines and was built combining the best components of individual disciplines of CMM(Software CMM, People CMM, etc.). It can be applied to product manufacturing, people management, software development, etc.

CMM describes about the software engineering alone where as CMM Integrated describes both software and system engineering. CMMI also incorporates the Integrated Process and Product Development and the supplier sourcing.

## CMMI and Business Objectives

The objectives of CMMI are very obvious. They are as follows −

* **Produce quality products or services** − The process-improvement concept in CMMI models evolved out of the Deming, Juran, and Crosby quality paradigm: Quality products are a result of quality processes. CMMI has a strong focus on quality-related activities including requirements management, quality assurance, verification, and validation.
* **Create value for the stockholders** − Mature organizations are more likely to make better cost and revenue estimates than those with less maturity, and then perform in line with those estimates. CMMI supports quality products, predictable schedules, and effective measurement to support the management in making accurate and defensible forecasts. This process maturity can guard against project performance problems that could weaken the value of the organization in the eyes of investors.
* **Enhance customer satisfaction** − Meeting cost and schedule targets with high quality products that are validated against customer needs is a good formula for customer satisfaction. CMMI addresses all of these ingredients through its emphasis on planning, monitoring, and measuring, and the improved predictability that comes with more capable processes.
* **Increase market share** − Market share is a result of many factors, including quality products and services, name identification, pricing, and image. Customers like to deal with suppliers who have a reputation for meeting their commitments.
* **Gain an industry-wide recognition for excellence** − The best way to develop a reputation for excellence is to consistently perform well on projects, delivering quality products and services within cost and schedule parameters. Having processes that conform to CMMI requirements can enhance that reputation.

## CMMI Discipline Selection

Selecting a discipline may be a difficult step and depends on what an organization wants to improve.

* If you are improving your systems engineering processes, like Configuration Management, Measurement and Analysis, Organizational Process Focus, Project Monitoring and Control, Process and Product Quality Assurance, Risk Management, Supplier Agreement Management etc., then you should select Systems engineering (SE) discipline. The discipline amplifications for systems engineering receive special emphasis.
* If you are improving your integrated product and process development processes like Integrated Teaming, Organizational Environment for Integration, then you should select IPPD. The discipline amplifications for IPPD receive special emphasis.
* If you are improving your source selection processes like Integrated Supplier Management then you should select Supplier sourcing (SS). The discipline amplifications for supplier sourcing receive special emphasis.
* If you are improving multiple disciplines, then you need to work on all the areas related to those disciplines and pay attention to all of the discipline amplifications for those disciplines

The CMMI is structured as follows −

* Maturity Levels (staged representation) or Capability Levels (continuous representation)
* Process Areas
* Goals: Generic and Specific
* Common Features
* Practices: Generic and Specific

## Continuous vs Staged Representations

|  |  |
| --- | --- |
| Continuous Representation | Staged Representation |
| Process areas are organized by process area categories. | Process areas are organized by maturity levels. |
| Improvement is measured using capability levels. Capability levels measure the maturity of a particular process across an organization; it ranges from 0 through 5. | Improvement is measured using maturity levels. Maturity levels measure the maturity of a set of processes across an organization: it ranges from 1 through 5. |
| There are two types of specific practices: base and advanced. All specific practices appear in the continuous representation. | here is only one type of specific practice. The concepts of base and advanced practices are not used. All specific practices appear in the staged representation except when a related base-advanced pair of practices appears in the continuous representation, in which case only the advanced practice appears in the staged representation. |
| Capability levels are used to organize the generic practices. | Common features are used to organize generic practices. |
| All generic practices are included in each process area. | Only the level 2 and level 3 generic practices are included. |
| Equivalent staging allows determination of a maturity level from an organization's achievement profile. | There is no need for an equivalence mechanism to back the continuous representation because each organization can choose what to improve and how much to improve using the staged representation. |

A maturity level is a well-defined evolutionary plateau toward achieving a mature software process. Each maturity level provides a layer in the foundation for continuous process improvement.

CMMI models with staged representation, have five maturity levels designated by the numbers 1 through 5. They are −

* Initial
* Managed
* Defined
* Quantitatively Managed
* Optimizing

## CMMI Staged Representation Maturity Levels

The following image shows the maturity levels in a CMMI staged representation.

## 

## Maturity Level Details

Maturity levels consist of a predefined set of process areas. The maturity levels are measured by the achievement of the **specific** and **generic goals** that apply to each predefined set of process areas. The following sections describe the characteristics of each maturity level in detail.

## Maturity Level 1 Initial

At maturity level 1, processes are usually ad hoc and chaotic. The organization usually does not provide a stable environment. Success in these organizations depend on the competence and heroics of the people in the organization and not on the use of proven processes.

Maturity level 1 organizations often produce products and services that work; however, they frequently exceed the budget and schedule of their projects.

Maturity level 1 organizations are characterized by a tendency to over commit, abandon processes in the time of crisis, and not be able to repeat their past successes.

## Maturity Level 2 Managed

At maturity level 2, an organization has achieved all the specific and generic goals of the maturity level 2 process areas. In other words, the projects of the organization have ensured that requirements are managed and that processes are planned, performed, measured, and controlled.

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.

At maturity level 2, requirements, processes, work products, and services are managed. The status of the work products and the delivery of services are visible to management at defined points.

Commitments are established among relevant stakeholders and are revised as needed. Work products are reviewed with stakeholders and are controlled.

The work products and services satisfy their specified requirements, standards, and objectives.

## Maturity Level 3 Defined

At maturity level 3, an organization has achieved all the specific and generic goals of the process areas assigned to maturity levels 2 and 3.

At maturity level 3, processes are well characterized and understood, and are described in standards, procedures, tools, and methods.

A critical distinction between maturity level 2 and maturity level 3 is the scope of standards, process descriptions, and procedures. At maturity level 2, the standards, process descriptions, and procedures may be quite different in each specific instance of the process (for example, on a particular project).

At maturity level 3, the standards, process descriptions, and procedures for a project are tailored from the organization's set of standard processes to suit a particular project or organizational unit. The organization's set of standard processes includes the processes addressed at maturity level 2 and maturity level 3. As a result, the processes that are performed across the organization are consistent except for the differences allowed by the tailoring guidelines.

Another critical distinction is that at maturity level 3, processes are typically described in more detail and more rigorously than at maturity level 2. At maturity level 3, processes are managed more proactively using an understanding of the interrelationships of the process activities and detailed measures of the process, its work products, and its services.

## Maturity Level 4 Quantitatively Managed

At maturity level 4, an organization has achieved all the specific goals of the process areas assigned to maturity levels 2, 3, and 4 and the generic goals assigned to maturity levels 2 and 3.

At maturity level 4, sub-processes are selected that significantly contribute to the overall process performance. These selected sub-processes are controlled using statistical and other quantitative techniques.

Quantitative objectives for quality and process performance are established and used as criteria in managing the processes. Quantitative objectives are based on the needs of the customer, end users, organization, and process implementers. Quality and process performance are understood in statistical terms and are managed throughout the life of the processes.

For these processes, detailed measures of process performance are collected and statistically analyzed. Special causes of process variation are identified and, where appropriate, the sources of special causes are corrected to prevent future occurrences.

Quality and process performance measures are incorporated into the organization's measurement repository to support fact-based decision making in the future.

A critical distinction between maturity level 3 and maturity level 4 is the predictability of process performance. At maturity level 4, the performance of processes is controlled using statistical and other quantitative techniques, and is quantitatively predictable. At maturity level 3, processes are only qualitatively predictable.

## Maturity Level 5 Optimizing

At maturity level 5, an organization has achieved all the specific goals of the process areas assigned to maturity levels 2, 3, 4, and 5 and the generic goals assigned to maturity levels 2 and 3.

Processes are continually improved based on a quantitative understanding of the common causes of variation inherent in processes.

This level focuses on continually improving process performance through both incremental and innovative technological improvements.

The quantitative process-improvement objectives for the organization are established, continually revised to reflect changing business objectives, and used as criteria in managing process improvement.

The effects of deployed process improvements are measured and evaluated against the quantitative process-improvement objectives. Both the defined processes and the organization's set of standard processes are targets of measurable improvement activities.

Optimizing processes that are agile and innovative, depends on the participation of an empowered workforce aligned with the business values and objectives of the organization. The organization's ability to rapidly respond to changes and opportunities is enhanced by finding ways to accelerate and share learning. Improvement of the processes is inherently a role that everybody has to play, resulting in a cycle of continual improvement.

A critical distinction between maturity level 4 and maturity level 5 is the type of process variation addressed. At maturity level 4, processes are concerned with addressing special causes of process variation and providing statistical predictability of the results. Though processes may produce predictable results, the results may be insufficient to achieve the established objectives. At maturity level 5, processes are concerned with addressing common causes of process variation and changing the process (that is, shifting the means of the process performance) to improve process performance (while maintaining statistical predictability) to achieve the established quantitative process-improvement objectives.

## Maturity Levels and Process Areas

|  |  |  |  |
| --- | --- | --- | --- |
| LEVEL | Focus | Key Process Area | Result |
| Optimizing | Continuous Process Improvement | Organizational Innovation and Deployment  Causal Analysis and Resolution | Highest Quality / Lowest Risk |
| Quantitatively Managed | Quantitatively Managed | Organizational Process Performance  Quantitative Project Management | Higher Quality / Lower Risk |
| Defined | Process Standardization | Requirements Development  Technical Solution  Product Integration  Verification  Validation  Organizational Process Focus  Organizational Process Definition  Organizational Training  Integrated Project Management (with IPPD extras)  Risk Management  Decision Analysis and Resolution  Integrated Teaming (IPPD only)  Org. Environment for Integration (IPPD only)  Integrated Supplier Management (SS only) | Medium Quality / Medium Risk |
| Managed | Basic Project Management | Requirements Management  Project Planning  Project Monitoring and Control  Supplier Agreement Management  Measurement and Analysis  Process and Product Quality Assurance  Configuration Management | Low Quality / High Risk |
| Initial | Process is informal and Adhoc |  | Lowest Quality / Highest Risk |

# **Capability Levels:**

# **Capability 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.

## This is tantamount to Maturity Level 1 in the staged representation.

# **Capability Level 1: Performed**

A Capability Level 1 process is a process that is expected to perform all of the Capability Level 1 specific and generic practices. Performance may not be stable and may not meet specific objectives such as quality, cost, and schedule, but useful work can be done. This is only a start, or baby-step, in process improvement. It means that you are doing something but you cannot prove that it is really working for you.

# **Capability Level 2: Managed**

A managed process is planned, performed, monitored, and controlled for individual projects, groups, or stand-alone processes to achieve a given purpose. Managing the process achieves both the model objectives for the process as well as other objectives, such as cost, schedule, and quality. As the title of this level indicates, you are actively managing the way things are done in your organization. You have some metrics that are consistently collected and applied to your management approach.

Remember: metrics are collected and used at all levels of the CMMI, in both the staged and continuous representations. It is a bitter fallacy to think that an organization can wait until Capability Level 4 to use the metrics.

# **Capability Level 3: Defined**

A capability level 3 process is characterized as a "defined process." A defined process is a managed (capability level 2) process that is tailored from the organization's set of standard processes according to the organization's tailoring guidelines, and contributes work products, measures, and other process-improvement information to the organizational process assets.

# **Capability Level 4: Quantitatively Managed**

A capability level 4 process is characterized as a "quantitatively managed process." A quantitatively managed process is a defined (capability level 3) process that is controlled using statistical and other quantitative techniques. Quantitative objectives for quality and process performance are established and used as criteria in managing the process. Quality and process performance is understood in statistical terms and is managed throughout the life of the process.

# **Capability Level 5: Optimizing**

An optimizing process is a quantitatively managed process that is improved, based on an understanding of the common causes of process variation inherent in the process. It focuses on continually improving process performance through both incremental and innovative improvements. Both the defined processes and the organization's set of standard processes are targets of improvement activities.

# **CMMI Capability Areas:**

# **CMMI Players - Roles Responsibilities**

Note that one person can fulfill many of these roles simultaneously or serially, depending on the size of your organization and the complexity of your process improvement (PI) effort.

# **Process Improvement**

Process improvement efforts generally require the following individuals and groups −

* **PI Sponsor** − The person from the organization responsible for over-seeing the entire PI effort. This person generally has the power to allocate funds and personnel. This person is usually at the directorate level or above.
* **PI Champion** − This is the public relations person for the PI effort, who may or may not serve as the EPG Lead. This person markets the idea, approach, and results of PI.
* **Engineering Process Group (EPG) Lead** − This person leads the group that reviews processes. This person assigns tasks to the EPG members, monitors their efforts, and plans the daily duties of the EPG.
* **EPG Members** − These individuals serve on the EPG as committee members. They are responsible for ensuring that process improvement documentation is written and followed. They are also responsible for generating metrics to track the process improvement process. They lead the PATs.
* **Process Action Teams (PATs)**− These teams generate the process improvement documentation, policies, processes, procedures, charters, and Action Plans.
* **Transition Partner** − Usually one or two individuals who are outside consultants brought in to help set up, plan, lead, and monitor progress in organizational process improvement. These individuals bring experience doing process improvement from several other organizations and industries.

**CMMI – Appraisals**

The CMMI Appraisal is an examination of one or more processes by a trained team of professionals using an appraisal reference model as the basis for determining strengths and weaknesses of an organization.

Appraisals require planning. When planning an appraisal of your organization, determine the scope of the organizational unit, which disciplines to include, whether the appraisal team will consist of members internal or external to your organization, projects to be included, individuals to be interviewed, and the type or class of appraisal necessary.

Appraisals consider three categories of model components as defined in the CMMI −

* **Required** − specific and generic goals only.
* **Expected** − specific and generic practices only.
* **Informative** − includes sub-practices and typical work products.

## Appraisal Class Characteristics

Each class is distinguished by the degree of rigor associated with the application of the method. Class A is the most rigorous, Class B is slightly less rigorous, and Class C is the least rigorous. Following table gives some idea of the expected differences between the methods in each class.

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristics** | **Class A** | **Class B** | **Class C** |
| Amount of objective evidence gathered | High | Medium | Low |
| Rating generated | Yes | No | No |
| Resource needs | High | Medium | Low |
| Data sources (instruments, interviews, and documents) | Requires all three data sources | Requires only two data sources (one must be interviews) | Requires only one data source |
| Appraisal team leader requirement | Authorized Lead Appraiser | Authorized Lead Appraiser or person trained and experienced | Person trained and experienced |
| Team size | Large | Medium | Small |