

Using Integrity to Help Achieve CMMI Maturity Level 3

Introduction

As companies strive for more controlled and consistent software development processes, the Software Engineering Institute's (SEI) Capability Maturity Model[®] Integration (CMMI[®]) continues to be a leading framework for measuring and improving organizations' engineering processes. While there are individual Capability Maturity Models (CMM) for many disciplines (i.e. systems engineering, software engineering, software acquisition, workforce management and development), the Capability Maturity Model Integration is a framework that accommodates multiple disciplines in a cohesive set of integrated models that can be adopted by those currently using other CMMs, as well as by those new to the CMM concept. It is not a process description, but is meant to provide guidance when improving existing processes or developing new processes. This paper can help organizations that are trying to implement processes that are compliant with the CMMI. It focuses on providing an understanding of what requirements and tools are necessary for an organization to reach CMMI maturity level 3, particularly the CMMI-SE/SW version of the model for systems engineering and software engineering.

There are two representations of CMMI, staged and continuous. The staged representation represents the process areas in CMMI within maturity levels while the continuous representation presents capability levels that can be obtained within individual process areas. The rest of this paper will use staged representation terminology, however, what is stated for maturity levels 2 and 3 can usually be related to the continuous representation's capability levels 2 and 3, as well.

Predictability, effectiveness, and control of an organization's processes improve as an organization moves up the CMMI levels. Starting with maturity level 2, each maturity level is composed of several process areas that indicate the practices an organization should focus on to improve its software and systems engineering processes. The set of Practice Areas (PAs) that make up level 3 on the five level scale builds upon the level 2 PAs (often employed for individual projects) and implements the processes using a more organization wide focus than at level 2. Central to this effort should be a process-centric change management solution, which provides the control necessary for implementing CMMI-compliant processes. Here are some of the key reasons companies move to maturity level 3 CMMI:

- Bids to win contracts, particularly with the government, often require a maturity level of three or higher.
- Vendors who are incorporating many components from different suppliers often require suppliers to upgrade their maturity level to meet vendor quality or process standards.
- The organization has a need for developing and maintaining high quality applications/products, while at the same time increasing efficiency and productivity.
- Performance of various projects and programs are inconsistent and fall below acceptable standards.
- Regulatory commissions such as the FDA or FCC may have more stringent demands for staying within regulatory guidelines.
- Executive and senior management performance reviews may be based upon their organizations obtaining a specific level of software process and quality improvements.

Overview of the Capability Maturity Model Maturity Levels

CMMI is a model for assessing the engineering processes of an organization and for identifying the practices that are required to increase the maturity of these processes. The CMMI describes the principles and best practices underlying a mature engineering process and is intended to help Using Integrity to Help Achieve CMMI Maturity Level 3 Page 3 of 9 organizations improve their processes in terms of an evolutionary path from ad hoc, chaotic processes to mature, disciplined processes. The CMMI is organized into five maturity levels:

Initial

The Initial maturity level is by default where organizations are when they start their journey towards process maturity improvement. The software process at this level is characterized as ad hoc, and occasionally even chaotic. Few processes are defined and success depends on individual effort and heroics. Often even the processes that are in place are ignored. This is not a level that is “achieved,” so it is not covered within the CMMI as the other levels are.

Repeatable

At maturity level 2, the repeatable level, basic management processes are established to plan and track project cost, schedule, risks and functionality. Quality auditing and traceability of requirements throughout the entire development life cycle are also emphasized during this phase. The necessary process discipline is established to repeat earlier successes on projects with similar applications. There are seven maturity level 2 PAs and they form the basic foundation for all future improvement areas.

Defined

At maturity level 3 the processes for both management and engineering activities are documented, standardized, and integrated into a standard process for the organization. Each development life cycle approved for use within the organization is documented. At maturity level 2 every major project or application group could conceivably use different processes

as long as they were documented and used consistently within their own group. At level 3, however, the focus is on having an organizational standard, and all projects must follow the organizational standards or an approved, tailored version of those standards for developing and maintaining software. At level 3, the maturity level 2 compliant processes remain in place, with at least 11 more maturity level 3 PAs added for CMMI-SE/SW. Besides the focus on establishing organizational standard processes and repositories, the level 3 PAs also cover all of the engineering practices from requirements development through implementation, verification and validation, organizational training, managing process improvement at the organizational level and some advanced project management practices, e.g., risk management.

Managed

Organizations that achieve a CMMI maturity level beyond level 3 are considered highly mature. At maturity level 4 sophisticated measures of the process performance and product quality are collected and analyzed to stabilize and improve key processes and product quality. This level includes two PAs, but many companies utilize aspects of level 4 even if their goal is not to actually attain this level.

Optimizing

At maturity level 5 continuous process improvement becomes deeply embedded within the organization’s culture. As in level 4 a heavy reliance on measurements is used to identify what to improve through the implementation of innovative ideas and technologies, the results of which are also measured. There are three PAs at this level.

Generic Practices

Each PA within each maturity level has the same set of generic practices applied to it. Ten generic practices are applied for maturity level 2 and two more generic practices for level 3. The intent of the generic practices is to ensure the processes associated with each PA become institutionalized. For example, some of the generic practices include having a policy, a process description, planning, training, management oversight, measurements, sufficient resources, and stakeholder involvement for the processes associated with each PA.

Achieving Level 3 CMMI with Integrity, a PTC product

The remainder of this paper will focus on the role PTC can play in implementing processes that are compliant with CMMI level 3 PAs.

PTC offers a flexible, application lifecycle management platform allowing organizations to manage, build, package and release software across multiple platforms and environments with global software development teams. Organizations that use Integrity to assist their Software Process Improvement (SPI) program achieve improved software quality, process consistency, and IT governance. Integrity assists in bringing control to your development environment, while accelerating the Return on Investment (ROI) for the SPI initiative.

Organizational Process Focus (OPF) PA

CMMI defines OPF as a coordination of activities for developing and improving processes at all levels of the organization and across all functions within the organization. By gathering and analyzing the strengths and weaknesses of the existing processes, activities can be initiated to provide improvements. In cases where it is appropriate, standards are then implemented across the organization to serve as the new baseline for all development projects. Moving an organization to level 3 requires a company-wide project plan that is composed of tasks and initiatives aimed at achieving process improvement. The process improvement plan is the central work product necessary for establishing the CMMI maturity level 3 commitments.

Organization Process Definition (OPD) PA

OPD is closely tied to OPF as it utilizes the planned and coordinated activities that result from the OPF-related processes. All of the organization's process assets, including all standards developed to promote repeatable and well-defined software development life cycles, are collected, maintained, measured and made available for current use and for future process improvement. This is where Integrity can help. With the process management capabilities of Integrity, an organization can quickly map their chosen, defined processes using a graphical workflow modeler. Once Integrity has been populated with the necessary custom framework and desired processes, all workflows are automatically controlled and can be enforced as necessary. The automation of the processes ensures repeatability and allows the Project or Development Manager to concentrate on more important aspects of the project such as resource allocation and optimization. Configurable Portfolio capability within the product, coupled with reporting enables real time metrics and analysis derived directly from lifecycle activities facilitates accurate reporting to senior management and other relevant stakeholders within the organization. While all of the functionality described above can be implemented independently, PTC consultants can assist companies in defining and automating existing processes within Integrity. Through onsite workshops PTC consultants facilitate a group discussion where formal and informal processes are exposed and examined in depth – what do they look like now and how would the organization like them to develop over time? Once the processes have been defined, PTC consultants can help fine tune Integrity functionality, instituting triggers with the solution for approval cycles, escalation procedures and so on for maximum process automation.

Integrated Project Management (IPM) PA

The IPM PA involves somewhat advanced concepts not widely practiced in most software development organizations. IPM requires that organizational standards exist, as well as, strict guidelines for tailoring those standards. Understanding what the guidelines are and where they are stored, and also how they are modified and applied is an important task that must be accomplished in order to satisfy the requirements of this PA. Once again, we are talking about the management of multiple versions of documents. And as stated previously, if documents are work products, and all work products can be version controlled, then Integrity provides an excellent way to maintain and control the documents. Integrity provides a secure and flexible configuration management (CM) environment for versioning and storing and sharing documents, requirements and source code across distributed and local development teams. Its policies and server-defined preferences assist in defining and implementing centrally managed processes and procedures, which is critical to IPM. And because Integrity is seamlessly integrated with Integrity's process and workflow abilities, users can easily create and track connections between high level issues and low-level code changes using change packages. Developers and project managers alike can benefit from change packages to increase the traceability of changes and increase productivity.

Engineering PAs – Requirements Development (RD), Technical Solution (TS), Product Integration (PI), Verification (VER), and Validation (VAL)

Even though even maturity level 1 software organizations develop work products, engineering practices are not fully addressed within CMMI until maturity level 3. Here the processes and activities of the engineering process are identified and defined within the five PAs listed above. Integrity can be especially beneficial whenever a process workflow model is used in the software development environment. In fact it drives much of the activity inside the solution. For example, the graphical workflow modeler allows an organization to define its own states, workflow, workflow transitions and permissions. They can determine WHAT stages and in WHICH order issues will move, WHO will be able to make these transitions and determine any MANDATORY field requirements to apply at each stage. If necessary, more than one workflow may be created to suit the varying needs of different sectors or departments in the organization.

Including within the Verification PA is the important practice of performing peer reviews.

Peer Reviews, though a maturity level 3 practice, are often implemented by maturity level 2 organizations because of their superior "bang for the buck." When return on investment (ROI) is an important factor for whether or not an organization moves forward with Level 3, it is important to find the areas that are easily measured and can most effectively provide cost saving analysis. Peer Reviews is one of those areas. The discovery of defects or issues early in the development life cycle by peers increases the quality and integrity of the finished product and ultimately leads to financial savings as bug fixes become less costly. Each review of a work product from requirements specifications to test plans, from design documents to code, can result in saving time, effort, and money when found in the review process rather than the later stages of testing, or worse yet, "in the box" after the customer uses the product. Integrity provides two built in features supporting peer reviews: Project-level branching and optional staged change package review. Most CM tools permit file-level branching, however, Integrity supports it at the project level where speculative work can be done on a development path. At the desired time, i.e. at review readiness time, a checkpoint can be made on the development path and the state of the variant project reviewed as of that checkpoint. If the review does not find any issues of concern, then the changes can be migrated to the main development path in a single change package. Staged change package review is useful if processes are being strictly enforced by the Project Manager. In that case, the review process can be enabled to allow for a peer or management review before a change is committed to the repository.

Organizational Training (OT) PA

The Organizational Training PA requires establishing and maintaining a consistent training program that manages training across the organization. The benefit of having a PA dedicated to training is that it strengthens the commitment to implementing CMMI level 3 successfully. Rather than hit and miss training, which may be difficult to track and control, the OT PA involves planning and tracking the activities for training. Integrity's process and workflow is ideal for tracking a training program because of its limitless flexibility and high degree of configurability. For example, the state and workflow building blocks can be used to set up an "issue type" specifically for training. Managers and frontline developers can then submit and track information regarding past, present and future training sessions. Once this information is stored in the database, managers can quickly and easily run reports to determine whether the offerings are sufficient for their organization to be compliant with CMMI level 3.

Communication

When all of the documentation, processes, and procedures for an organization are stored in one location, immediate communication efficiencies can be realized. We have already discussed how Integrity provides the repository necessary for storing all this information and how it makes it easy for an organization to tailor individual project processes while maintaining the integrity of all work products. The last step is to make sure that anyone within the organization, or within the customer base with permission to review the organization's documentation, has secure and easy access to the information. Clearly, however, access to the documentation, processes, and procedures must be secure. PTC provides the access, but most importantly, provides safety and security of the information being accessed. As Integrity is a true client/server tool, all users requiring access must identify themselves by logging into the Integrity Server and adhering to the chosen Authentication Realm. Supported realms include LDAP, UNIX, and NT, which in most cases means users can reuse a username and password that they and their IT department are already familiar with. This avoids the need to administer another set of user credentials and reduces the administrative burden.

Metrics and Reporting

In the field of process improvement, metrics and trending play a vital role in assessing and verifying performance against maturity goals. Key metrics prescribed for CMMI level 3 include among others, cost variance – the difference between actual and budgeted costs; schedule variance – the difference between budgeted cost for work and work scheduled; and software defect trends. Using Integrity's portfolio capability, these metrics can be directly mined from the lifecycle processes and activities at work in the development organization. Unlike other Project and Portfolio management tools, which provide information based on estimations, and require manual data entry and updates to schedules, PTC Portfolios presents metrics and data in real time, and offers drill down ability allowing process managers to move from dashboards and charts directly into the lifecycle, for root cause analysis.

Assessing Cost versus Benefit

Pursuing CMMI-based process improvement requires a company to ask themselves "what are the benefits gained versus the substantial effort it takes to achieve this level of control?" The effort required to achieve maturity level 3 imposes training costs, process changes and infrastructure changes upon the organization and upon the development teams. Depending upon implementation, some process improvement initiatives can also mean increased time to market and additional production costs due to added development overhead. The decision to pursue CMMI level 3 is, therefore, a business decision and should be approached from a cost vs. benefit perspective. This is especially true for small to mid-sized companies where absorbing these costs may prove problematic. Integrity offers a high degree of process flexibility that mitigates the risk of overwhelming the development organization with new processes and infrastructure. It does this by supporting teams and/or projects that may have diverse process needs. It allows an organization to start with teams or projects that have a small and lightweight process footprint, and then enhance or add to this as the need arises. This experience can then be extended to more teams and projects that benefit from a reduced learning curve and lower administrative overhead. In this way, it is possible to have common, organization-wide standards that are tailored for specific groups or projects.

Conclusion

The main focus at CMMI maturity level 3 is “Defined.” It must be remembered that CMMI is a discipline that a company and its personnel must embrace and enforce. No tool can, by itself, get a company to the next level. Products like Integrity can only facilitate the achievement of the various CMMI levels – they do not drive the movement. Only discipline and dedication can make this possible if it is determined that the value of the CMMI Level 3 outweighs the costs of achieving it.

Appendix I – Case Study: Lockheed Martin

Quality and standards can have a profound effect on a company’s software configuration management (SCM) requirements and development processes. Teams with different quality requirements use different development processes. An example of one such company who successfully integrated different team requirements is Lockheed Martin. They successfully used Integrity to achieve a CMMI-SE/SW Level 5 rating. It is an ongoing effort for Lockheed Martin IT (LMIT), the IT contractor at Washington State’s Hanford nuclear site, to maintain and advance their CMMI-SE/SW rating beyond level 3. As a part of this important rating, over 250 developers and contractors at the Hanford site must use the Integrity SCM feature set to manage their software development, procedures, reporting, and statistics.

This is done mainly for quality reasons, but also for critical health and safety reasons. For example, if workers are entering a potentially contaminated area, they must be 100 percent certain that monitoring equipment is functioning properly. “Do you think I want someone walking into a plutonium finishing plant with bad statistics on air samples?” asks LMIT’s Configuration Manager. At Hanford, good quality software can literally mean the difference between life and death. Implementing an SCM system, in this case Integrity was a major contributor to LMIT obtaining its CMMI Level 5 rating. As the Configuration Manager explained, “If you look at CMMI, everything is based on configuration management. Everything... If you don’t have configuration management, you have nothing. All of our procedures that we interpret and put into play are maintained under Integrity. All of our statistics and reporting requirements that show we are compliant with federal regulations are maintained with this system. There isn’t too much that we don’t maintain with it.”

Appendix II – Preliminary Checklist for Basic CMMI Objectives

Questions focusing on change control: Are there processes in place to identify critical roadblocks to change control? How are changes to the work products identified, documented, tracked, and resolved once the development stage begins? Are project requirements under any change control discipline?

Questions focusing on release management: Are there processes in place to document and manage issues surrounding packaged releases? Does the current lifecycle allow for checkpoints or gateway reviews to determine product and process readiness at each phase of a release? Who within each project team is authorized to identify, publish, and/or mitigate the risk of issues surrounding project releases? What sort of signoff procedures are in place for approving changes and promoting pieces of the project to different staging areas or to the next phase of each release? Are enough controls in place to fully identify what actually makes up a release when it goes to production? Are project releases scheduled, created, and managed at the start of a project or are they bundled, as various development pieces are ready?

Questions focusing on defects and issues: How are defects initiated, documented, tracked, and resolved? What sort of impact analysis work is done to resolve issues, defects, conflicts, and other potential delays or quality impacts to a release? Where are the decisions made for inserting defects and issues into the current release? What types of code review or documentation review processes are in place? Are test cycles risk based or requirements based?

Questions focusing on general lifecycle discussion: Are individual roles and responsibilities clearly defined for the team members in each project? Is there a process in place for auditing and assessing the overall lifecycle process and for change management as it relates to each phase of the lifecycle? Are security controls in place to prevent access to work products at various phases of the project life cycle? Are there any programs for standards or centralized process improvement initiatives that will affect project releases in the immediate future? In the next 6 months? In the next 24 months? How involved will the individual groups be in developing the standard set of processes for the enterprise change management system?

Questions focusing on project management: Are project plans shared with all groups within the organization involved with the development and delivery of the project? Are all aspects of training, reviews, and coordination efforts planned and estimated within the project plan and schedule?

Questions focusing on implementation: Do all projects use the same database and same platform configuration? Are hardware changes necessary in order to install any tools that will assist in the creation of an enterprise change management system? Are individuals or teams in place to administer and maintain hardware and software implementations for an enterprise change management system?

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