



Rational Software Whitepaper

Achieving Capability Maturity Model[®] Integration (CMMI[®]) Maturity Level 2 Using IBM Rational[®] Software's Solutions

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This paper addresses how a company, organization, or project can leverage IBM Rational® Software's process and tool solutions as a viable means toward the achievement of a Capability Maturity Model® Integration (CMMI®) SE/SW Version 1.1 maturity level 2 appraisal rating.

For those organizations that have already adopted IBM Rational solutions, this paper offers valuable information on how to achieve a CMMI maturity level 2 rating. The paper identifies how the Rational Unified Process® (RUP®), Version 2002.05.00 and the application of IBM Rational tools and services, along with your organization's processes could meet many of the CMMI goals.

For organizations looking to engage in a process improvement initiative, this paper will show that by adopting RUP and IBM Rational integrated tools, they may achieve their goals more expeditiously, while establishing a solid foundation for a CMMI maturity level 3 effort.

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SECTION 1: OVERVIEW

As the first in a series of papers designed in a modular form, this paper provides a goal-level overview of the CMMI maturity level 2, and how IBM Rational solutions help satisfy the goals of ML 2. Additional modules will be available that address each CMMI process area (PA) in more detail by listing each practice, its description, the RUP role that might be responsible for satisfying the practice, what RUP process and procedure/template might help satisfy the practice, and any other observations that might be relevant. In situations where IBM Rational solutions do not fully address a practice, recommendations are made on how the organization might satisfy the practices to attain CMMI compliance. These additional modules can be found (as they become available) on the IBM Rational website at www.rational.com/solutions/industry/govt/cmmi.jsp.

Background of the CMMI

Over the past two decades, the Capability Maturity Model for Software (SW-CMM) has been the predominant tool for assessing and improving an organization's software development maturity. Following the success of the SW-CMM, various models were developed for other disciplines, including:

- Systems Engineering Capability Model (SECM) – EIA/IS-731
- Software Acquisition CMM
- Integrated Product Development CMM

Some large organizations even developed their own, customized CMMs such as the Federal Aviation Administration's integrated CMM (FAA-iCMM).

Ironically, the success of these CMMs also introduced many drawbacks. While the models were designed to guide organizations toward higher maturities, the underlying structures were different. Some, like the SW-CMM, advocated a "staged" approach that pre-defined process areas organizations should focus on as they reached "maturity levels". Others, like the SECM, implemented a "continuous" approach where organizations could choose to improve maturity within a process area independent of other process areas.

Significant overlap was also present between these models, particularly in the areas of project management, requirements, and process definition.¹

The results of these drawbacks were a higher cost of implementation due to additional training, certifications, expertise required, process engineering, assessments/appraisals, etc. Confusion was also introduced because of the models' differing representations, overlap, terminology, use within the organization, and so on.

As a remedy, the Software Engineering Institute (SEI) at Carnegie Mellon University (www.sei.cmu.edu/cmmi) launched the Capability Maturity Model Integration (CMMI) effort. The goals were to reduce the redundancy and complexity resulting from the use of separate, multiple capability maturity models, and to improve the efficiency of and the return on investment for process improvement. These goals would be met through the integration of several CMMs, and the creation of a product suite that provided frameworks for specified disciplines (or discipline combinations), training products, assessment materials, glossary terms, and tailoring requirements.¹

From the CMM to the CMMI: An Important Transition

The United States Department of Defense (DoD) originally commissioned the Capability Maturity Model for Software (SW-CMM) in response to the escalating costs and schedule overruns that were impacting projects and programs within the department. Software development results were no better in the commercial software industry. The Standish Group's landmark 1994 CHAOS Report showed that the average software project ran 189% over budget, and overshot its schedule by 222%.² The DoD needed a way to independently assess the software engineering capabilities of software suppliers, while simultaneously providing them roadmap for improvement.

The CMM offered the DoD that objective measuring stick. With five increasingly higher levels of software capability as a gauge, the CMM clearly demonstrated the benefits of increased software development maturity. Software organizations operating at SW-CMM Maturity Level 3 are 65% more productive than those at SW-CMM ML 1, reduce project costs and schedule by 20%, and deliver 80% less defects. CMM ML 3 organizations also deliver projects with better cost and schedule predictability.³

¹ From the "Concept of Operations for the CMMI", www.sei.cmu.edu/cmmi/background/conops.html

² "The CHAOS Study", The Standish Group International, inc., Dennis, MA, 1994

³ "Measuring Software Process Improvement", Capers Jones, Software Productivity Research, 2001

Additionally, organizations outsourcing software development projects are increasingly looking for increased software development maturity from their vendors via independent CMM-based assessments. Those suppliers that wish to deliver better results to their customers are engaging in CMM-based software process improvement efforts.

As the SEI transitions from the CMM to the CMMI, more and more organizations will adopt the new, integrated model. The SEI has stopped updating the SW-CMM and plans on discontinuing training for the SW-CMM by the end of 2003. SW-CMM Lead Assessors and Lead Evaluators will be given until the end of 2005 to transition to the new CMMI appraisal method.

The CMMI provides many benefits, and leading companies are making the transition to it in order to implement a standardized, integrated approach towards software and systems engineering in their organizations.

Initiating a Process Improvement Project

Generally, those organizations seeking to improve their engineering capabilities first conduct a CMMI-based, independent, informal appraisal. This appraisal is based on the Appraisal Requirements for CMMI v1.1 (ARC) Class B and C methods developed by the SEI, and it identifies strengths in the organization, as well as weaknesses, compared to the CMMI model. Class B and C methods of appraisals are less rigorous and far less costly than the more formal Standard CMMI Appraisal Method for Process Improvement (SCAMPI) Class A method which should be undertaken only when the organization is ready for and confident of achieving a Maturity Level.

Leading organizations simultaneously conduct a financial appraisal of the organization, such as the cognence, inc. "Cost of Quality Appraisal" (www.cognence.com/CostofQualityAppraisalOne-Sheet.pdf), which sets the baseline for the organization's engineering financial performance. This appraisal provides the business case for an improvement effort, and allows improvement results to be measured from a dollars and cents perspective.

Weaknesses (gaps) identified in the Class B or C informal appraisal can then be translated into an action plan, and the organization can work to resolve the weaknesses. Weaknesses may range from not performing the required practices that support CMMI goals, to a general lack of institutionalization of behaviors in the organization, to a lack of documented plans and procedures.

Once the organization has addressed the appraisal action items, a formal SCAMPI appraisal may be conducted to verify that the organization has indeed resolved the weaknesses, and achieved the desired CMMI maturity level. A follow up Cost of Quality Appraisal can specifically show the financial benefits of process improvement by comparing the organization's cost allocation prior to, and after the effort.

Accelerating CMMI Maturity with Tools and Best Practices from IBM Rational

IBM Rational is the leading provider of integrated solutions, combining market-leading tools, software engineering best practices, and services, which automate the software development process. For more than 20 years, IBM Rational has helped software teams overcome chronic development obstacles through a flexible and proven approach that results in higher-impact software, a more motivating work environment, and a greater return on software development investments. For more information on Rational, see www.rational.com.

The goal of the CMMI is to create better quality software by improving the processes that are used to create project deliverables. A process is a sequence of steps performed for a given purpose, and integrates people, methods and procedures, and tools (See Figure 1).⁴

⁴ "The Capability Maturity Model", Carnegie Mellon University, 1994

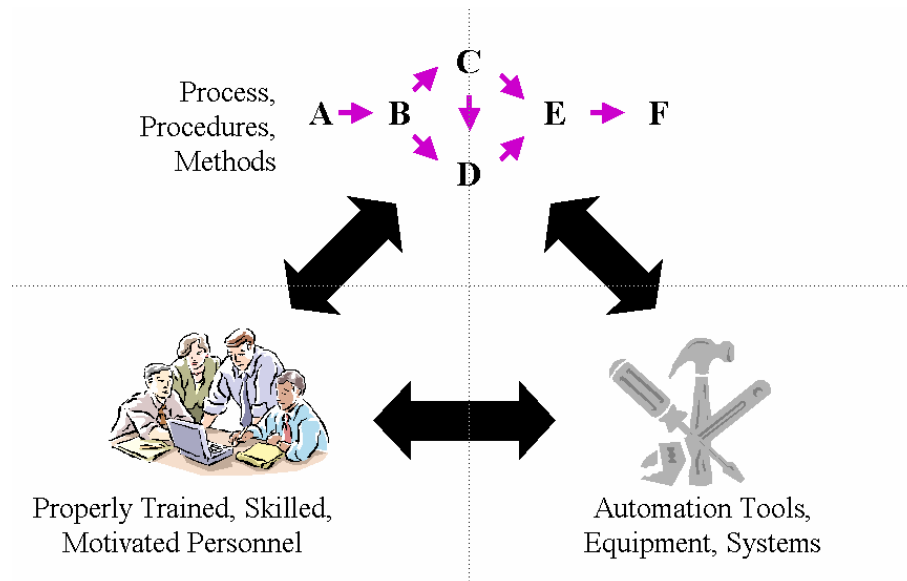


Figure 1

IBM Rational brings solutions to bear in all three process dimensions

The Rational Unified Process® integrates proven software engineering best practices to deliver a world-class software development process, methods, procedures, templates, and more through an easy-to-use, intuitive web interface. RUP provides a foundation that covers a large percentage of the requirements stated by the CMMI. This foundation can be used to address the CMMI across the project, not just the software portion of the project.

IBM Rational also provides an integrated suite of tools that automates many aspects of the software development process, including requirements management, configuration and change management, visual modeling, automated testing, and more. Tools from IBM Rational are integrated with RUP, and when used appropriately, provide a near seamless process to tool interface.

Rational University enables organizations to make the most effective use of RUP and IBM Rational tools through comprehensive process and product training course offerings. IBM Rational also provides professional services to get an implementation up and running so organizations can enjoy the benefits of higher software quality and improved productivity more quickly.

Through the proper implementation of IBM Rational integrated software engineering best practices and automation tools, an organization can accelerate the attainment of CMMI maturity level 2, and have a solid foundation for maturity level 3. While other organizations are defining and documenting processes and procedures, trying to integrate disparate tools, and internally creating custom training, Rational-enabled organizations are reaping the benefits higher process maturity provides.

Assumptions

The CMMI appraisal model essentially follows the “Say what you do, Do what you say, Prove it” concept. This means that organizations that wish to achieve a CMMI maturity level 2 rating must document various engineering methods and procedures (“Say what you do”), execute them as documented (“Do what you say”), and be able to prove they are following their methods and procedures via quality records and/or project artifacts (“Prove it”). During an appraisal, the appraisal team verifies compliance with the CMMI goals through examination of objective evidence in the form of direct artifacts, indirect artifacts, and affirmations. Direct artifacts are things directly produced by implementing the expected practice (e.g., a project plan, a configuration management plan), while indirect artifacts are things which show the practice was implemented but aren’t a direct result of the practice (e.g., meeting minutes showing something was reviewed). Affirmations are written or oral statements indicating that a certain practice was performed. SCAMPs are verification-based appraisals and will also conduct interviews of selected project participants in order to corroborate the objective evidence.

For an organization to effectively use this white paper, certain assumptions are implicit:

1. The organization has adopted the Rational Unified Process (RUP).
2. The organization is following RUP as documented, and has made appropriate changes to reflect how the project or organization performs tasks.
3. The organization is creating the artifacts as requested by the Rational Unified Process, applying the critical thinking needed to make proper use of the templates.
4. The organization has a plan on how to implement RUP as part of its process improvement activities.
5. The organization schedules a review by an independent appraisal team, in order to ensure appropriate implementation against the CMMI. .
6. The CMMI uses terminology in a very specific manner that must be understood by the organization prior to use of the model.
7. The organization has chosen or is in the process of choosing whether they will use the CMMI's staged representation or the continuous representation.
8. This paper is not intended to describe the CMMI in detail. For complete CMMI information, see the SEI site.
9. This paper should not be considered training on either the staged or continuous representations of the CMMI.
10. This paper is not intended to be a complete description of how a project can satisfy the CMMI requirements. The CMMI is a model, and as such, the solutions to CMMI requirements a project identifies can be very different than those outlined here.
11. This paper does not provide training on any of the associated engineering or project management activities. For training there are numerous entities such as Rational University, SEI, IEEE, PMI, INCOSE, or formal University teachings that provide direction on courses, or courses themselves.
12. It is important to recognize that the compliance of any organization with maturity level requirements of the CMMI are based on the integration and institutionalization of the organization's processes. Tools can greatly aid in the implementation of and reduce effort associated with processes, but any tool in itself does not guarantee that all the requirements of the model are being met. The organization must implement processes that comply with the CMMI requirements first. The processes and templates provided by RUP will automate many of the required process steps and provide objective evidence in the form of plans, records, etc., however it is still the responsibility of the organization to ensure its overall process implementation meets all the requirements of the desired maturity level.
13. The Rational Unified Process evaluated in this whitepaper is version 2002.05.00.

CMMI OVERVIEW

This section provides an overview of the CMMI, and at a high-level, how IBM Rational solutions can satisfy CMMI goals in each maturity level 2 process area. This section is only intended to be an overview. Additional detailed information on the CMMI can be found at the SEI website at www.sei.cmu.edu/cmmi. An excellent resource describing the CMMI is the book “*CMMI Distilled*“, by Dennis M. Ahern, Aaron Clouse, and Richard Turner, ISBN 0-201-73500-8.

As they become available, more detailed information on how IBM Rational solutions satisfy CMMI maturity level 2 process areas will be accessible via CMMI Process Area Modules on The IBM Rational website at www.rational.com/solutions/industry/govt/cmmi.jsp.

The CMMI SE/SW V1.1 model consists of 22 process areas. A process area is a cluster of related practices that, when performed collectively, satisfy a set of goals considered important for making significant improvement in a given area. All CMMI process areas are common to both continuous and staged representations. In the staged representation, process areas are organized by maturity levels with each process area pre-defined to exist in only one maturity level.⁵ In the continuous representation a given process area's maturity is called its capability level and each process area can exist at any of the six capability levels independent of any other process area. Thus the term maturity level refers to a predefined group of process areas that all exist at the same level of maturity, whereas the term capability level refers only to an individual process area.

Continuous vs. Staged Representation

The CMMI can be applied via the continuous representation, or via the staged representation. The continuous representation allows an organization to select the order of improvement that best meets the organization's business objectives and mitigates the organization's areas of risk. The staged representation provides 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.⁵ More detail regarding each representation is found later.

To fully satisfy a process area, both the generic goals and the specific goals must be satisfied. Specific goals apply to a process area and address the unique characteristics that describe what must be implemented to satisfy the process area. Specific goals are required model components and are used in appraisals to help determine whether a process area is satisfied. Specific goals are supported by specific practices, which are activities that are considered important in achieving the associated specific goal. The specific practices describe the activities expected to result in achievement of the specific goals of a process area. Specific practices are expected model components.⁵

Generic goals are called “generic” because the same goal statement appears in multiple process areas. In the staged representation, each process area has only one generic goal. Achievement of a generic goal in a process area signifies improved control in planning, implementing, and controlling 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. Generic goals are supported by generic practices that provide institutionalization to ensure that the processes associated with the process area will be effective, repeatable, and lasting. Generic practices are categorized by generic goals and common features and are expected components in CMMI models.⁵

Refer to Figure 2 for a pictorial view of CMMI's staged representation structure.

⁵ From “*CMMI Integration, Version 1.1 – Staged Representation*” found at www.sei.cmu.edu/cmmi

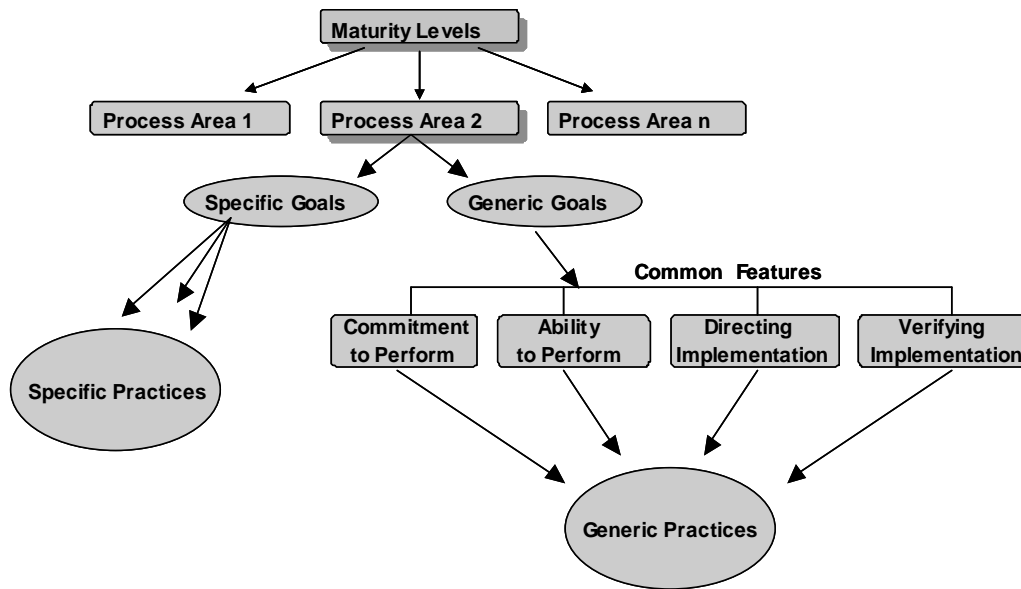


Figure 2
Pictorial view of CMMI's staged representation structure

While the next section of this paper describes the continuous representation, the general purpose of this paper is to explain how IBM Rational solutions help organizations achieve CMMI maturity level 2 using the staged representation. CMMI maturity level 2 focuses on implementing a management capability at the project level for all activities, with the goal of institutionalizing these capabilities so that in times of stress, they are not discarded. The result is an organization that can better estimate and deliver products on-time, on-budget, and with better quality.

The material contained herein generically describes how IBM Rational solutions support the attainment of CMMI's maturity level 2 goals. Specific details (at the practice level) regarding each CMMI maturity level 2 process area are contained in additional modules available at www.rational.com/solutions/industry/govt/cmmi.jsp as they become available.

Description of the Continuous Representation

The continuous representation of the CMMI allows an organization to focus on its capability, and on the improvement, of a single process area, or on multiple specific process areas in ways that do not map into pre-defined stages. Each process area has its associated specific goals, similar to the staged representation. Each capability level from 1 through 5 has an associated generic goal and associated generic practices. The 22 process areas are consistent across both the continuous and staged representations. Note that in the staged representation there are no requirements for maturity level 1, whereas in the continuous representation there are specific and generic goals which are required to reach capability level 1. This increased granularity of capability (process maturity) allows organizations to show progress much sooner than might otherwise be possible. This can be important in organizations that are under senior management pressure to show immediate results.

For ease of thought and process improvement use, the 22 process areas (PAs) themselves are divided into four process categories:

- Process Management – 5 PAs
- Project Management – 6 PAs
- Engineering – 6 PAs
- Support – 5 PAs

By choosing one process area, or by choosing a single process category, an organization can concentrate its improvement efforts on those areas it has decided are most important to its business goals, imperatives, or problems.

Each of the 22 process areas can be individually characterized by the CMMI as being:

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.⁶

Capability Level 1 - Performed: A performed process is a process that satisfies the specific goals of the process area. It supports and enables the work needed to produce identified output work products using identified input work products. A critical distinction between an incomplete process and a performed process is that a performed process satisfies all of the specific goals of the process area.⁶ There is a single generic goal at capability level 1 which requires that the basic specific practices of the process area are implemented.

Capability Level 2 - Managed: A managed process is a performed (capability level 1) process that is also planned and executed in accordance with policy, employs skilled people having adequate resources to produce controlled outputs, involves relevant stakeholders; is monitored, controlled, and reviewed; and is evaluated for adherence to its process description. The process may be instantiated by an individual project, group, or organizational function. Management of the process is concerned with the institutionalization of the process area and the achievement of other specific objectives established for the process, such as cost, schedule, and quality objectives.

A critical distinction between a performed process and a managed process is the extent to which the process is managed. A managed process is planned (the plan may be part of a more encompassing plan) and the performance of the process is managed against the plan. Corrective actions are taken when the actual results and performance deviate significantly from the plan. A managed process achieves the objectives of the plan and is institutionalized for consistent performance.⁶ There is a single generic goal at capability level 2 which requires that the process area be institutionalized as a managed process. This generic goal has ten generic practices which address the policy, plans, resources, training, management, and objective oversight provided over the process area.

Capability Level 3 - Defined: 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.

A critical distinction between a managed process and a defined process is the scope of application of the process descriptions, standards, and procedures. For a managed process, the process descriptions, standards, and procedures are applicable to a particular project, group, or organizational function. As a result, the managed processes for two projects within the same organization may be very different. At the defined capability level, the organization is interested in deploying standard processes that are proven and that therefore take less time and money than continually writing and deploying new processes. Because the process descriptions, standards, and procedures are tailored from the organization's set of standard processes and related organizational process assets, defined processes are appropriately consistent across the organization. Another critical distinction is that a defined process is described in more detail and performed more rigorously than a managed process. This means that improvement information is easier to understand, analyze, and use. Finally, management of the defined process is based on the additional insight provided by an understanding of the interrelationships of the process activities and detailed measures of the process, its work products, and its services.⁶ There is a single generic goal at capability level 3 which requires that the process area be institutionalized as a defined process. It has two generic practices which address the establishment of the project's defined processes and collection of improvement information.

Capability Level 4 - Quantitatively Managed: 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. The quality and process performance are understood in statistical terms and are managed throughout the life of the process.

A critical distinction between a defined process and a quantitatively managed process is the predictability of the process performance. The term "quantitatively managed" implies using appropriate statistical and other quantitative techniques to manage the performance of one or more critical subprocesses of a process so that the future performance of the process can be predicted. A defined process only provides qualitative predictability.⁶ There is a single generic goal at capability level 4 which requires that the process area be

⁶ From "CMMI Integration, Version 1.1 – Continuous Representation" found at www.sei.cmu.edu/cmmi

institutionalized as a quantitatively managed process. It has two generic practices which address the establishment of quantitative objectives for the process area and the stabilization of one or more subprocesses that are considered critical to achieving the quantitative objectives.

Capability Level 5 - Optimizing: An optimizing process is a quantitatively managed (capability level 4) process that is changed and adapted to meet relevant current and projected business objectives. An optimizing process focuses on continually improving the process performance through both incremental and innovative technological improvements. Process improvements that would address root causes of process variation and measurably improve the organization's processes are identified, evaluated, and deployed as appropriate. These improvements are selected based on a quantitative understanding of their expected contribution to achieving the organization's process-improvement objectives versus the cost and impact to the organization. The process performance of the organization's processes is continually improved.

A critical distinction between a quantitatively managed process and an optimizing process is that the optimizing process is continuously improved by addressing common causes of process variation and providing statistical predictability for the results. Though a level 4 process may produce predictable results, the results may be insufficient to achieve the established objectives. In a process that is optimized, common causes of process variation are addressed by changing that process in a manner that will lead to a shift in the mean or a decrease in variation when it is brought back to stability. These changes are intended to improve process performance and achieve the organization's established process-improvement objectives.⁶ There is a single generic goal at capability level 5 which requires that the process area be institutionalized as an optimizing process. It has two generic practices that ensure continuous process improvement and identifying/correcting root causes of problems.

Organizations utilizing the continuous representation can find themselves at differing capability levels in various process areas, as illustrated by Figure 3.

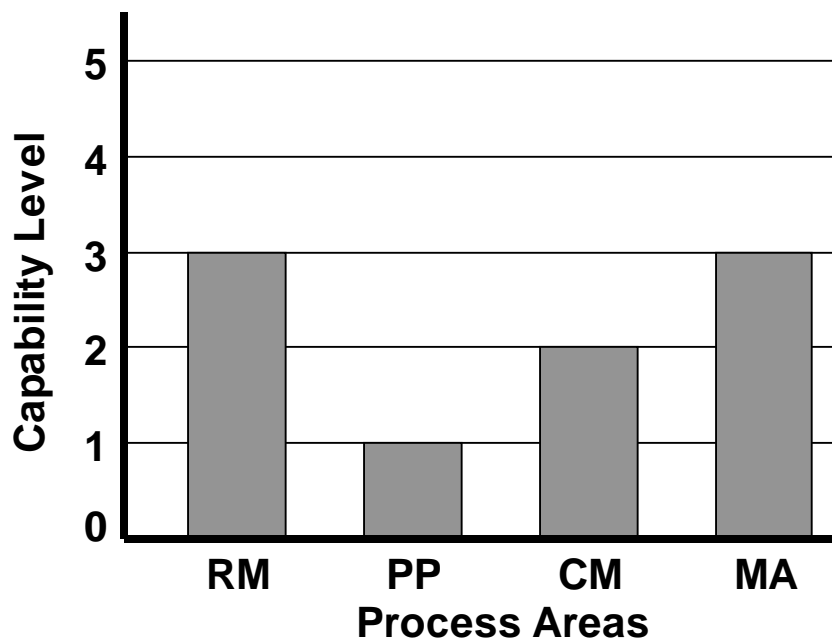


Figure 3

Description of the Staged Representation

The staged representation of the CMMI focuses on organizational maturity. The staged representation consists of 22 process areas, each of which is assigned to one of 5 maturity levels (ML). Each process area consists of one or more specific goals, and one or more generic goals. Each goal has an associated set of defined practices. The practices of the generic goals can be identified as belonging to the common features of Commitment to Perform, Ability to Perform, Directing Implementation, and Verifying Implementation. The staged representation forces an organization to concentrate on a predefined set of process areas to attain each maturity level. An appraisal against the model allows an organization to be appraised at a given maturity level 1 through 5. The five levels and their definitions include:

Maturity Level 1 – Initial: At ML 1, processes are usually ad hoc and chaotic. The organization usually does not provide a stable environment. Success in these organizations depends on the competence and heroics of the people in the organization and not on the use of proven processes. In spite of this ad hoc, chaotic environment, maturity level 1 organizations often produce products and services that work; however, they frequently exceed the budget and schedule of their projects. ML 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.⁵

Maturity Level 2 – Managed: At ML 2, an organization has achieved all the specific and generic goals of the ML 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 ML 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.⁵

Maturity Level 3 – Defined: At ML 3, an organization has achieved all the specific and generic goals of the process areas assigned to MLs 2 and 3. At ML 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 ML 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.

A critical distinction between ML 2 and ML 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 ML 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 ML 2 and ML 3. As a result, the processes that are performed across the organization are consistent except for the differences allowed by the tailoring guidelines.⁵

Maturity Level 4 - Quantitatively Managed: At ML 4, an organization has achieved all the specific goals of the process areas assigned to MLs 2, 3, and 4 and the generic goals assigned to MLs 2 and 3. Subprocesses are selected that significantly contribute to overall process performance. These selected subprocesses are controlled using statistical and other quantitative techniques. Quantitative objectives for quality and process performance are established and used as criteria in managing 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.⁵

Maturity Level 5 – Optimizing: At ML 5, an organization has achieved all the specific goals of the process areas assigned to MLs 2, 3, 4, and 5 and the generic goals assigned to MLs 2 and 3. Processes are continually improved based on a quantitative understanding of the common causes of variation inherent in processes. ML 5 focuses on continually improving process performance through both incremental and innovative technological improvements. 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.⁵

Refer to Figure 4 for a pictorial representation of the CMMI staged representation.⁷

⁷ From "CMMI v1.1 Tutorial" by Mike Phillips

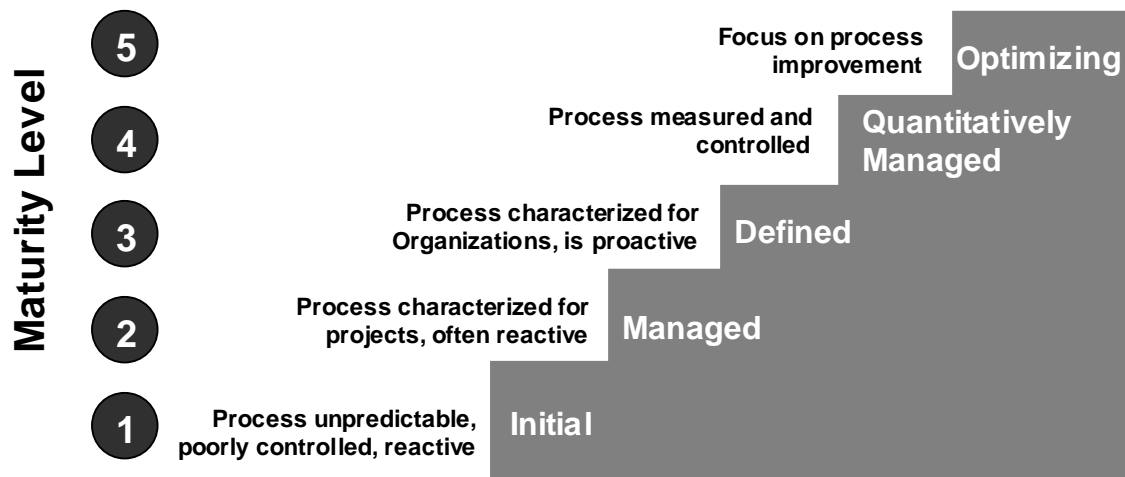


Figure 4

In the CMMI's staged representation, there are seven process areas present at maturity level 2, and are discussed in more detail later in the paper. The PAs are:

1. Requirements Management (REQM)
2. Project Planning (PP)
3. Project Monitoring and Control (PMC)
4. Supplier Agreement Management (SAM)
5. Measurement and Analysis (MA)
6. Process and Product Quality Assurance (PPQA)
7. Configuration Management (CM)

Description of CMMI Maturity Level 2 Generic Goals and Practices

The CMMI's maturity level 2 has a single generic goal stated as:

Generic Goal 2 (GG 2) – The process is institutionalized as a managed process

This generic goal must be satisfied for each of the maturity level 2 process areas. The intent of this goal is that a project puts in place, follows, and sustains a set of processes. Satisfying this generic goal shows that an organization has institutionalized the processes for all the maturity level 2 process areas.

The generic practices that map to the generic goal includes practices for the project to:

- Follow a policy,
- Plan its process and its work,
- Provide resources and assigns responsibility to perform the process and project work,
- Train its personnel on the process, tools, and additional required knowledge for each process area,
- That the project manages and controls work products and processes,
- Evaluate how well it adheres to the identified process, and
- Review project status with project management and senior management.
-

Again, the generic goal and its generic practices apply to each of the maturity level 2 process areas.

In the staged representation maturity level 2, the 10 generic practices that map to the generic goal are categorized by common features.

Commitment to Perform

Generic Practice 2.1 (CO 1) – Establish and maintain an organizational policy for planning and performing process

The purpose of this common feature is for senior management to become involved and to provide guidance to the organization. This communication and support needs to be visible to all personnel and should include guiding principles, direction, and high-level expectations. This common feature is used to ensure the projects, and the project personnel understand what tasks they must perform to ensure they operate in the best interest of the organization while they perform activities for each of the process areas.

For each PA, the CMMI requires that a written organizational policy be in place and followed by the organization via the Commitment to Perform common feature. RUP does not specifically address the need for policies (or a single, overarching policy), although the Software Engineering Process Authority (SEPA) described in RUP would be the appropriate entity to help develop the policies.

Ability to Perform

Generic Practice 2.2 (AB 1) – Establish and maintain the requirements and objectives, and plan for performing the process

Generic Practice 2.3 (AB 2) – Provide adequate resources for performing the process, developing the work products, and providing the services of the process

Generic Practice 2.4 (AB 3) – Assign responsibility and authority for performing the process, developing the work products, and providing the services of the process

Generic Practice 2.5 (AB 4) – Train the people performing or supporting the process as needed

The purpose of this collection of four practices under this common feature is to ensure that:

- Project personnel understand the reasons for performing a process, and have collected and documented those requirements
- Each project documents and controls their requirements in a manner that all project personnel have appropriate access to the requirements
- Project management plans and schedules the work consistent with the requirements
- Each task and deliverable is assigned to project personnel
- Project personnel are trained to perform their job duties as they relate to each process area
- Accountability and responsibility for performing the process on each project is specifically assigned to an individual

Resources and funding are required by the CMMI's Ability to Perform common feature. Organizations can map the required CMMI resources to RUP roles, keeping in mind the CMMI activities those roles are responsible for have to be performed, even if RUP does not address them. Of course, funding must be provided for the roles to be able to effectively perform their responsibilities. The RUP activity Project Management->Develop Software Development Plan->Define Project Organization & Staffing is the appropriate place to define and plan for the necessary roles.

The CMMI's Ability to Perform common features also require various roles and groups in the organization to be trained or oriented in their specific job function. Informal training/orientation can be provided by the RUP itself. It is web-based and can be available to all project team members via a web browser. Rational University provides many classes and workshops where formal engineering process and tool training can be acquired. Finally, a large number of books have been published that focus on RUP and the various best practices it advocates. Note however, that the CMMI suggests more comprehensive training in job functions than may be received if training is only concerned with RUP or the IBM Rational tool suite.

The CMMI requires that various plans and procedures be documented and available to the organization. RUP provides many IEEE-based templates including the software development plan, software configuration management plan, and software quality assurance plan. Since these templates provide instructions on how to complete the templates, they are considered to be procedures by the CMMI. If completed fully and correctly, the resulting plans could be used to document other procedures required by the CMMI that are not specifically addressed by RUP itself.

To accomplish this each organization should review and modify/expand the templates as necessary to ensure that other CMMI process area goal requirements or other specific organization requirements are accommodated.

Directing Implementation

Generic Practice 2.6 (DI 1) – Place designated work products of the process under appropriate levels of configuration management

Generic Practice 2.7 (DI 2) – Identify and involve the relevant stakeholders as planned

Generic Practice 2.8 (DI 3) – Monitor and control the process against the plan and take appropriate corrective action

The purpose of this collection of three practices under this common feature is to ensure that:

- Configuration control is maintained for managing the project documents, plans, specifications, and deliverables
- Stakeholders are communicated with according to plan
- The project plan and schedule is monitored to ensure the tasks and deliverables are being completed, but more importantly, to provide management indicators of when the project is not advancing according to the plan. This oversight gives decision makers an opportunity to identify and take actions to correct the project direction.

Generic practice 2.6 can be satisfied by following RUP's Configuration Management discipline, ensuring that the various work products created and maintained by the project are identified, their level of configuration control documented, and that they are managed and controlled as documented.

The process can be monitored, and stakeholders can be involved as identified and planned through various RUP-required project reviews found in the Monitor Project Status activity of RUP. The RUP calls out various reviews including:

1. Project Approval Review
2. Project Planning Review
3. Iteration Plan Review
4. PRA Project Review
5. Iteration Criteria Evaluation Review
6. Iteration Acceptance Review
7. Lifecycle Milestone Review
8. Project Acceptance Review

It is important during these reviews to focus not only on product progress, but also on the process creating the products.

If identified project stakeholders attend the appropriate meetings, the process is monitored, controlled, and action taken when required, and review records are kept, generic practices 2.7 and 2.8 can easily be satisfied. However care should be taken to recognize that the stakeholders referred to in this generic practice 2.6 includes representatives from non-project related organizations such as, but not limited, to the organization's engineering process group, organizational configuration management and quality groups, and senior managers interested in process improvement throughout the organization. Who these relevant stakeholders are varies widely across organizations and proactively identifying them is one purpose of generic practice 2.7.

Verifying Implementation

Generic Practice 2.9 (VE 1) – Objectively evaluate adherence of the process and work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance

Generic Practice 2.10 (VE 2) – Review the activities, status, and results of the process with higher-level management and resolve issues

The purpose of these two practices under this common feature is to ensure that

1. Checks are in place to evaluate the project activities for each process area and the work products created.
2. Project activities and deliverables map to the project plan, schedule, and process.
3. The results of these evaluations can then be reviewed with both project and senior management for decision-making purposes and to ensure that higher levels of management are both interested in and kept aware of the state of process related activities within the organization

Two levels of reviews are required by the CMMI's Verifying Implementation common feature: senior management, and quality assurance. The RUP calls out various reviews including:

1. Project Approval Review
2. Project Planning Review
3. Iteration Plan Review
4. PRA Project Review
5. Iteration Criteria Evaluation Review
6. Iteration Acceptance Review
7. Lifecycle Milestone Review
8. Project Acceptance Review

Senior management reviews can be accommodated by the RUP's PRA project review. This review requires that the project's senior management review the project's process activities and milestones. An outcome of this review is the Review Record. Appraisal teams will look to the Review Record for objective evidence that higher level management reviewed not only the projects activities and status, but also the status of the process area's activities compared to the plan.

Objective evidence of compliance with CMMI-required objective evaluations can be easily satisfied by having the individual or organizational entity performing the objective evaluation represented at the project reviews noted above and documenting in the Review Record their activities and status reports. Although the CMMI does not specifically require it, most organizations satisfy this portion of the CMMI through involvement of a Quality Assurance or equivalent functional group.

Description of CMMI Maturity Level 2 Process Areas and Specific Goals

Requirements Management (RM)

The purpose of the Requirements Management Process Area 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

Only one specific goal is required to be satisfied in this process area for CMMI Maturity Level 2:

Specific Goal 1 (SG 1) – Requirements are managed and inconsistencies with project plans and work products are identified

Project personnel need to have a consistent understanding of what is included in the scope of work of the project. Most projects experience some level of requirements change or churn over the life of the project. On a small project with few people and few requirements, this may not appear to be significant. As projects become larger it becomes more difficult to communicate these changes to all personnel. Thus the work products tend to drift from what the client has specified and agreed to. The intent of this process area is to ensure project plans, schedules, work products and deliverables stay consistent with the requirements.

The initial elicitation, analysis, and allocation of requirements to hardware, software, and other system components is handled within Requirements Development, a staged maturity level 3 process area. It is after the requirements have been identified that the Requirements Management process area becomes involved. Compliance with this

process area is aided by good configuration management of the requirements and the associated process that ensures all relevant stakeholders are considered in the change process. RUP and the Rational tool suite describe many of these processes and provide the means to automate configuration management of the requirements and other work products. CM provides the basis for the organization to review the impacts of any changes to the requirements on the project plans and other related items.

Project Planning (PP)

The purpose of the Project Planning Process Area is to establish and maintain plans that define project activities

There are three specific goals that need to be satisfied in this process area for CMMI Maturity Level 2:

Specific Goal 1 (SG 1) – Estimates of project planning parameters are established and maintained

Specific Goal 2 (SG 2) – A project plan is established and maintained as the basis for managing the project

Specific Goal 3 (SG 3) – Commitments to the project plan are established and maintained

Once requirements have been collected, the project tasks and deliverables can be planned and scheduled. The plan is a written document typically containing the schedule and additional project information. Completion time for each task and deliverable must be estimated, and the estimates along with the basis of the estimates must be captured for future project and organizational use. Project tasks and deliverables can then be scheduled (typically using a scheduling tool), with durations and resources assigned. Prior to finalization, the plan and schedule need to be agreed upon by both internal and external stakeholders. The plan and schedule must be controlled just as every project work product for the duration of the project. This helps to ensure the project personnel are working to the same plan, schedule, and therefore requirements.

RUP's Project Management discipline satisfies the majority of the Project Planning PA's goals, including the development of a project plan, and obtaining commitment to the plan.

Although RUP does require estimates to be prepared, it does not specify any one particular estimation method. Thus, the organization or project must select and document the specific procedures used to identify and estimate values for the product attributes that will be used to estimate task durations and costs.. Similarly, a procedure is required detailing how the project creates and updates its schedule.

RUP does contain links to the COCOMO II method of estimation. This may be a good starting point for organizations to look into when investigating appropriate estimation methods, however the COCOMO family of models only applies to software development while the CMMI applies to hardware, software, and other project components. It may be necessary to document and use a number of estimating methods.

Documentation of project risks, assessment, and mitigation strategies can be automated using the Rational ClearQuest product.

Project Monitoring and Control (PMC)

The purpose of the Project Monitoring and Control Process Area is to provide and understanding into the project's progress so that appropriate corrective actions can be taken when the project's performance deviates significantly from the plan

There are two specific goals that need to be satisfied in this process area for CMMI Maturity Level 2:

Specific Goal 1 (SG 1) – Actual performance and progress of the project is monitored against the project plan

Specific Goal 2 (SG 2) – Corrective actions are managed to closure when the project's performance or results deviate significantly from the plan

On every project, plans and schedules will change. To keep up with what is really occurring, the project management team needs to track the tasks and deliverables against the plan and schedule. Each project team member must be able to use the plan and schedule to ensure they are performing the correct tasks at the correct time.

to keep their deliverables on schedule. If a problem is encountered, the plan and schedule may need to be changed to provide ongoing insight into the project activities. These changes are inserted into the plan and schedule, which, once updated, should be redistributed to all the stakeholders. Only by tracking to the latest project knowledge can the project manager really understand the risks to timely delivery of the technical content required of the project within the established cost and schedule budgets. By using Rational ProjectConsole, project managers can obtain up-to-the-minute status on each of their projects.

Similar to the Project Planning PA, RUP's Project Management discipline satisfies the majority of the Project Monitoring and Control PA's goals, particularly in the ongoing tracking of the development effort through the Monitor Project Status activity.

The main aspect of PMC to keep in mind is the ongoing tracking of project risks, work product sizes, effort and costs, resources, etc. While tracking, if any actual data deviates significantly from the initial estimates, corrective action must be taken via the Handle Exceptions & Problems RUP activity.

Project risk tracking can be easily automated using Rational ClearQuest.

Supplier Agreement Management (SAM)

The purpose of the Supplier Agreement Management Process Area is to manage the acquisition of products and services from suppliers external to the project for which there exists a formal agreement

There are two specific goals that need to be satisfied in this process area for CMMI Maturity Level 2:

Specific Goal 1 (SG 1) – Agreements with the suppliers are established and maintained

Specific Goal 2 (SG 2) – Agreements with the suppliers are satisfied by both the project and the suppliers

Just as the project personnel need to understand their requirements, schedule, budget, and other pertinent project information and constraints, so do suppliers to the project. If a product or service is specified for purchase, and will be required by the project, both the project and the supplier need to understand what should be delivered and what is included in the contract.

RUP is intended to be used by an organization that typically develops software products or systems directly for a client organization. The CMMI takes into account the fact that often times there are multiple collaborating organizations working on pieces or tasks of a total system development effort. The CMMI assumes that one of these organizations is the "prime contractor", and the others are "suppliers". Suppliers typically use their own development processes, procedures, and tools to build or perform their respective parts of the system. Thus, many of the practices required by the CMMI in the Supplier Agreement Management PA are not specifically addressed by RUP.

However, an organization can become compliant in this PA by using the IEEE Std 1062 Recommended Practice for Software Acquisition. This standard outlines the recommended steps an organization should follow when undergoing a software acquisition effort. If the standard is utilized correctly, many of the SAM procedures asked for by the CMMI would be produced. Placing these agreements or other artifacts under CM control using the Rational tool suite would provide partial objective evidence of the “established and maintained” portions of the requirements from this process area.

Of course, a prime contractor using RUP might consider encouraging suppliers to follow RUP as well.

Measurement and Analysis (MA)

The purpose of the Measurement and Analysis Process Area is to develop and sustain a measurement capability that is used to support management information needs

There are two specific goals that need to be satisfied in this process area for CMMI Maturity Level 2:

Specific Goal 1 (SG 1) – Measurement objectives and practices are aligned with identified information needs and objectives

Specific Goal 2 (SG 2) – Measurement results that address identified information needs and objectives are provided

The CMMI's Measurement and Analysis process area require the organization to identify, collect, and use measurements that allow the organization to assess and improve their processes and work product quality. Measurements include project, product, and process data. Project data includes schedule, budget, and status of tasks and deliverables. Product data may include lines of code, numbers of defects, numbers of requirements, or measures of other product attributes. Process data may include effectiveness, timeliness, or measures of other process attributes of how the project processes are working. Each of these three areas must be considered to provide decision makers appropriate insight into the project activities. The measures collected can then be used to make decisions on this and other projects.

RUP recommends that a measurement plan be completed to specify the measurements that must be made and used. Then, these measurements can be reviewed and analyzed during the Project Review Authority (PRA) project reviews, or during the SEPA's periodic meetings. Many IBM Rational integrated tools, such as Rational ClearCase, ClearQuest, RequisitePro, and ProjectConsole provide more than adequate measurement gathering simply by automating the engineering process with them. However to show compliance with this process area will require additional work and documentation to show how the measures collected are aligned with the organization's business objectives. This process area also requires significant effort in precisely defining the measures that will be collected, how they will be collected, where they will be stored, how they will be analyzed, etc., and the organization must make sure that this detail is included in the measurement plan.

Process and Product Quality Assurance (PPQA)

The purpose of the Process and Product Quality Assurance Process Area is to provide staff and management with objective insight into the processes and associated work products

There are two specific goals that need to be satisfied in this process area for CMMI Maturity Level 2:

Specific Goal 1 (SG 1) – Adherence of the performed process and associated work products and services to applicable process descriptions, standards, and procedures is objectively evaluated

Specific Goal 2 (SG 2) – Noncompliance issues are objectively tracked and communicated, and resolution is ensured

Sometimes, under difficult circumstances, project tasks are not always performed correctly. Project personnel and management need to know that the correct tasks are being performed in the correct manner under all circumstances. The reviews of engineering activities and audits of project work products should be performed by a technically qualified, objective group. Project work (both tasks and deliverables) can be checked against the requirements, plan, project standards, and/or project process. When inconsistencies are identified, the issues can be documented, reported to the engineers and management, resolutions identified, and tracked to completion.

The CMMI's view of Quality Assurance encompasses more than just product quality. It also focuses on process quality. The underlying philosophy of the CMMI with regard to quality assurance is that “a quality process will produce a quality product”.

The clear intent of the CMMI is that senior management reviews the results of the objective reviews already accomplished to ensure that the processes are being followed, and one function of the PPQA process area is to ensure senior management is fulfilling its duties as required by generic practice 2.10. RUP's role of “Reviewer” engages in many of the CMMI required product reviews such as the SDP review. By including the RUP

“Reviewer” role in project and senior management status meetings, some of the CMMI required process reviews can be accommodated.

RUP does advocate the completion of a Software Quality Assurance Plan. This IEEE-based plan template, when completed properly, will address many of the CMMI PPQA requirements such as the product and process review requirements, and audit and deviation escalation procedures. Ultimately, however, the QA group must perform in accordance with the QA plan, and show evidence that it is doing so.

The Rational ClearQuest tool can be effectively used to document and track deviations identified during QA audits and reviews.

Configuration Management (CM)

The purpose of the Configuration Management Process Area is to establish and maintain the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits.

There are three specific goals that need to be satisfied in this process area for CMMI Maturity Level 2:

Specific Goal 1 (SG 1) – Baselines of identified work products are established and maintained

Specific Goal 2 (SG 2) – Changes to the work products under configuration management are tracked and controlled

Specific Goal 3 (SG 3) – Integrity of baselines is established and maintained

A constant on every project is change. Changes may include modifications to requirements, schedule, or budget. Changes to requirements typically cause a ripple effect through multiple work products, project interfaces, schedule, and budget. It is imperative that these various work products and deliverables stay consistent with each other, and with the requirements. The mechanism for ensuring this consistency is Configuration Management.

Project work products typically controlled include project documentation (plans, schedules, and other documents), and each release of a deliverable item such as a document, software, or hardware. Deliverables also typically include associated documentation such as requirements, users guides or manuals, version description documents or other similar documents. Each of these items should be considered for control so changes can be understood from one version to the next. Configuration management and control helps to ensure that a deliverable matches the specifying requirements.

The RUP discipline, Configuration and Change Management, satisfies much of the CMMI's Configuration Management requirements.

RUP requires that the Configuration Management Plan be completed and documented. This plan will detail many of the project-specific procedures necessary to complete the CM tasks. A high-level CM plan, in conjunction with product documentation or RUP tool mentors would not be sufficient for CMMI Level 2 since they provide general guidance, not project-specific procedures.

Many of the reports, audits, configuration statuses, and measurements can be automated using Rational ClearCase and ClearQuest. In fact, these tools were built specifically to assist organizations in performing their CM tasks better and more efficiently.

USING IBM RATIONAL SOLUTIONS TO SATISFY CMMI LEVEL 2

IBM Rational provides a number of products and services that help in reaching higher CMMI maturities. This section provides a brief overview of the applicable products and services, and how they help satisfy the various process areas and goals of CMMI maturity level 2. Recommendations are also given in those cases where IBM Rational solutions don't completely satisfy CMMI requirements.

For more detail on each Process Area, refer to the additional CMMI Process Area Modules that address each key practice, and the RUP role that might be responsible for satisfying the practice, what RUP process and procedure/template might help satisfy the practice, and any other observations/recommendations that might be relevant. As they become available, these modules can be found at www.rational.com/solutions/industry/govt/cmmi.

Rational Unified Process (RUP)

The Rational Unified Process, otherwise known as RUP, was developed by IBM Rational as a software engineering process providing a disciplined approach to assigning tasks and responsibilities within a software development organization. Key concepts of the RUP are:

1. Develop Iteratively
2. Manage Requirements
3. Use Component Architectures
4. Model Visually
5. Continuously Verify Quality
6. Manage Change

The RUP product provides a web-based process asset library describing a family of related software engineering processes sharing a common structure, and common process architecture. Its goal is to ensure the production of high-quality software that meets the needs of its end users, within a predictable schedule and budget. RUP captures many of the best practices in modern software development in a form that can be tailored to a wide range of projects and organizations. For more information on RUP, see www.rational.com/products/rup.

RUP is a valuable framework for satisfying many of the CMMI's maturity level 2 goals. The following lists each of RUP's disciplines applicable to maturity level 2, and the CMMI process area(s) they apply to:

- Requirements - CMMI Requirements Management PA
- Project Management - CMMI Project Planning PA, Project Monitoring & Control PA, Process and Product Quality Assurance PA, Measurement and Analysis PA
- Configuration & Change Management – CMMI Configuration Management PA, Measurement & Analysis PA
- Test – Measurement and Analysis PA
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The Environment discipline applies to several of the generic practices at CMMI maturity level 2. The activity Develop Development Case specifically addresses GP 2.2 Plan the Process practice by asking projects to tailor RUP to meet their specific requirements.

To fully satisfy CMMI goals, some additional activities must be performed that aren't specifically called out by RUP. These activities include:

- Creation of organizational policies that direct the planning and performing of CMMI ML 2 processes – RUP doesn't specifically call out the creation of policies by senior management for a project to use as guidance.
- Creation of detailed standards and procedures that address the day-to-day performance of all system and software engineering activities – RUP workflows and activities are generally at the process level. Some engineering activities, such as build procedures, project estimation, etc., need to be further documented in more detail.
- Process-oriented reviews – RUP calls out several levels of reviews, but they tend to focus on the products created by the software development process. By adding a process review dimension, and documenting the results, an organization can satisfy these CMMI requirements.

- Managing suppliers – RUP is designed to be used by an organization that typically develops software products or systems directly for a client organization. Thus, the Supplier Agreement Management Process Area is not specifically addressed by RUP. However, one way an organization can become compliant in this PA is by using the IEEE Std. 1062 Recommended Practice for Software Acquisition as a guideline for all supplier agreements, not just software acquisition. This standard outlines the recommended steps an organization should follow when undergoing a software acquisition effort. If the standard is implemented correctly, many of the Supplier Agreement Management Process Area requirements would be satisfied.

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By adopting RUP, an organization can shortcut the need to internally develop and document several of the required software development processes. The organization will need to tailor RUP and the templates to best meet its needs, to quickly take advantage of the proven best practices, guidelines, and other assets provided by RUP.

Rational ClearCase

Rational ClearCase® simplifies the process of change with a family of products that scales from small project workgroups to the distributed global enterprise. Rational ClearCase helps project teams control everything that evolves in development — including requirements, models, source code, and test scripts. Rational ClearCase offers the essential functions of version control, workspace management, process configurability, and build management. By automating many of the necessary, yet error-prone tasks associated with a development effort, Rational ClearCase enables teams of all sizes to build the highest-quality deliverables possible. For more information on ClearCase, see www.rational.com/products/clearcase.

Together with RUP, Rational ClearCase specifically addresses the goals of the configuration management process area. It also addresses the CMMI maturity level 2 generic practice 2.6 - Manage Configurations. ClearCase can also, when used properly, provide significant measurements and metrics that can be used to satisfy the Measurement and Analysis process area.

In order to be fully compliant in the Configuration Management process area at CMMI Maturity Level 2, organizations adopting ClearCase should ensure that they document the various procedures team members would use in interacting with the tool. These include:

- Role and procedures for a configuration control board or equivalent
- Check-in, check-out
- Delivery to integration stream
- Branching, merging, rebasing
- Build/baseline creation
- Generation of build report(s)
- Generation of audit report(s)
- Performance of audits

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Rational ClearQuest

Rational ClearQuest® is a powerful and highly flexible defect and change tracking system that captures and manages all types of change requests throughout the development lifecycle, helping organizations quickly deliver higher quality software. Compatible with Windows, UNIX, or the Web, the fully customizable interface and workflow engine adapt to any development process. With support for industry standard databases, ClearQuest scales to support projects of any size and integration with other development solutions ensures that your entire team is tied into the defect and change tracking process. For more information on ClearQuest, see www.rational.com/products/clearquest.

Together with RUP and ClearCase, ClearQuest provides a powerful change management capability that goes a long way towards satisfying the CMMI's Configuration Management process area, as well as aspects of the Requirements Management PA, the Measurement and Analysis PA, and the Process and Product Quality Assurance PA.

It is important for organizations pursuing a CMMI improvement effort to document how ClearQuest is used to manage changes, including the various procedures used to enter change requests, create reports and charts, etc.

ClearQuest can be used to support the Process and Product Quality Assurance PA by tracking results of process and work product audits, tracking and resolving non-compliance issues, reporting results to management, and maintaining records of quality assurance activities. ClearQuest has also been used to provide objective evidence of the “corrective actions” required in many other process areas by acting as an issues/action item tracking log.

Rational Unified Change Management (UCM)

Unified Change Management (UCM) is the IBM Rational approach to managing change in software development projects from requirements to release. UCM spans the development lifecycle, providing an out-of-the box approach to manage changes to requirements, design models, documentation, components, test cases, source code, etc. UCM is a pre-configured change process model that leverages a tight integration between Rational ClearCase and ClearQuest.

Organizations having difficulty managing change should seriously consider implementing UCM, since the process and tools can be implemented quickly, and the benefits of properly managing change realized faster. Over time, UCM can be tailored to better meet an organization's specific needs.

UCM addresses the CMMI requirements addressed by ClearCase and ClearQuest (see above), but in a much more expedited fashion. IBM Rational supports UCM through various training courses for administrators and practitioners, and supplies out-of-the box capabilities such as change request state models, configuration and change management reports, baseline and build management functions, and documentation.

Rational RequisitePro

Rational RequisitePro®, is a powerful, easy-to-use, integrated product for requirements management that uses Microsoft Word. RequisitePro lets you maintain the way you document requirements, while leveraging analytical capabilities such as requirements analysis, coverage and change impact. It promotes better communication, enhances teamwork and reduces project risk. For more information on RequisitePro, see www.rational.com/products/reqpro.

Rational RequisitePro's requirements management and traceability matrix capabilities help organizations satisfy the Requirements Management PA's goals by providing the capability to manage change to requirements through a project's lifecycle. Used correctly, RequisitePro will also help in keeping project work products, such as design documents, project plans, test plans, etc., in sync with project requirements.

Rational RequisitePro can also help in satisfying the Measurement and Analysis PA by providing valuable information to the organization regarding requirements changes, churn, and shifting priorities.

Rational ProjectConsole

Rational ProjectConsole®, an integral part of every Rational Suite, helps you monitor project progress, identify trends, and improve project predictability. It simplifies access to project information by creating a Web site with artifacts and metrics automatically collected from your development environment. Rational ProjectConsole integrates with Microsoft® Project and offers extensive graphical reporting and dashboard displays to give you and your team complete, up-to-date views of project progress.

Implementing Rational ProjectConsole in conjunction with RUP's Measurement Plan is an effective way to help automate the collection of measurements and reporting of metrics on a software project. Since Rational ProjectConsole can access information stored in various tool repositories, as well as other outside sources, it will help organizations satisfy the requirements outlined in the Measurement and Analysis PA.

Rational University

Rational University offers numerous on-line and in-person training courses that help organizations in Rational solution implementations. Courses range from the process oriented “Requirements Management with Use-Cases” class, to the more technical “Rational ClearCase MultiSite Administration” class. For more information on Rational University, see www.rational.com/university.

RU's process and product course offerings help in satisfying the CMMI's Maturity Level 2 Ability to Perform 2.5 generic practice common feature. These courses are invaluable to help organization quickly come up to speed on the new methods, best practices, and tools that will be used on projects.

Organizations should not just rely on RU to satisfy CMMI requirements, however. Additional training is expected for the Body of Knowledge each project team member's role requires, as well as organizational/project orientation and training to help team members understand how IBM Rational solutions are specifically implemented for their project.

Rational Professional Services

IBM Rational Professional Services are based on years of experience helping software development organizations, utilizing a worldwide staff of qualified consultant that help accelerate and ensure implementation of IBM Rational products and best practices. Besides consulting and mentoring, IBM Rational offers packaged service products as well as customized services.

When approaching a CMMI effort, bringing in experienced consultants can be the difference between success and failure. IBM Rational consultants help accelerate tool and process implementations through pre-packaged QuickStarts, provide the needed expertise to solidify the new practices and tools in the organization via consulting and mentoring, and assist in tailoring tools to meet specific organization's needs.

Through the combination of Rational University, and IBM Rational services, organizations can make the transition of new process and tool implementations permanently take hold, making the most of the company's IBM Rational investment.

SECTION 2: REQUIREMENTS MANAGEMENT PROCESS AREA

This RM paper is part of a continuing series of papers on how a company, organization, or project can leverage the processes and tools provided by IBM Rational® for achieving CMMI ML 2. At a high level, it describes how the CMMI views requirements management, and discusses how IBM Rational solutions satisfy the Requirements Management Process Area's specific and generic goals and practices. The scope of this paper is the Capability Maturity Model® Integration (CMMI®) Requirements Management process area maturity level 2 (CMMI ML 2) requirements. In cases where IBM Rational solutions do not fully address a practice, recommendations are made on how the organization might satisfy the practices to attain CMMI ML 2 compliance.

At the end of this paper a matrix is provided listing each CMMI RM goal/practice, its description, the Rational Unified Process (RUP) role that might be responsible for satisfying the practice, what RUP process, procedure, template, or IBM Rational tool might help satisfy the practice, and any other observations and recommendations that might be relevant.

Throughout this description, the use of italics indicates material taken directly from the CMMI.⁸

Further information on IBM Rational support for CMMI can be found on the Web at www.rational.com/solutions/industry/govt/cmmi.jsp.

Assumptions

The CMMI appraisal model is a verification-based audit that essentially follows the “Say what you do, do what you say, prove it” concept. This means that organizations that wish to achieve a CMMI maturity level 2 rating must document various management and engineering practices, execute them as documented, and be able to prove it by the existence of quality records and/or project artifacts. During an appraisal, an SEI Authorized Lead Appraiser and qualified appraisal team members look for objective evidence that the organization has implemented and institutionalized the practices. Objective evidence consists of direct artifacts, indirect artifacts, and affirmations. Direct artifacts are tangible work products directly created as a result of implementing a practice (e.g. a project plan or CM plan). Indirect artifacts are a side effect of implementing the practice or otherwise indicate the practice was performed (e.g., meeting minutes, reviews, logs). Affirmations are oral or written statements confirming or supporting the practice was implemented.

This paper makes the following organizational assumptions to show how IBM Rational solutions are utilized:

1. Adoption and implementation of the Rational Unified Process (RUP)
2. Use of the RUP as documented
3. Creation of the artifacts as defined by the RUP
4. Project plans which detail how the project team will implement the requirements management process area and describes the role of the RUP in that implementation

This paper will identify the various RUP roles, disciplines, templates and activities that would apply in satisfying the various CMMI maturity level 2 RM key practices.

The process area (PA) matrix attached to this paper lists each CMMI RM practice by goal (both specific and generic), its description, the RUP role that might be responsible for satisfying the key practice, what RUP process and procedure/template might help satisfy the key practice, and any notes that might be relevant. In situations where RUP does not fully address a key practice, suggestions are made in the notes column of the matrices on how the project might address the key practice to attain compliance.

The version of the CMMI that is addressed here is CMMI SE/SW V1.1. Additional detailed information on the CMMI can be found at the SEI Website at www.sei.cmu.edu/cmmi. An excellent resource describing the CMMI is the book “*CMMI Distilled*”, by Dennis M. Ahern, Aaron Clouse, and Richard Turner, ISBN 0-201-73500-8.

The Rational Unified Process, or RUP, evaluated in this paper is version 2002.05.00.

How to Get There

The combination of RUP, Rational RequisitePro, Rational ClearQuest, and Rational ClearCase, provide much of the solution needed to meet the CMMI ML 2 requirements in the Requirements Management (RM) process area.

For organizations that are adopting IBM Rational best practices and tools from the ground up, or those wanting to tailor already existing installations, the following steps provide a high-level framework for a successful implementation.

⁸ “CMMI Integration, Version 1.1 – Staged Representation” found at www.sei.cmu.edu/cmmi

1. Understand the current status of requirements management
 - a. Perform a CMMI-based appraisal of the requirements management process area in the organization
 - b. Document strengths, as well as gaps and deficiencies identified during the appraisal
2. Plan the implementation
 - a. Based on the results of the CMMI-based appraisal, determine the work products needed for successful implementation
 - i. Organizational policy
 - ii. Organizational requirements management plan template
 - iii. High-level organizational requirements management process (RUP)
 - iv. Create the development case, tailoring the requirements management activities and deliverables needed to properly mitigate project risk
 - v. Required documented procedures
 - vi. Project-specific RM orientation and training materials
 - vii. Measurements needed to support status of requirements management activities, and continuous improvement
 - b. Determine the steps necessary for successful implementation (a tailored version of this list)
 - c. Determine the number of resources required
 - i. Number of Rational RequisitePro, ClearQuest, ClearCase, and RUP licenses
 - ii. Other hardware and software resources to support the requirements management infrastructure
 - iii. Personnel to support the requirements management planning and rollout
 - iv. Personnel to support requirements management on an ongoing basis
 - v. Tool and process training
 - vi. Project-specific implementation training
 - b. Determine stakeholders who should review and approve the RM rollout plan
 - c. Determine if out-of-the-box UCM will be implemented, or the customized Rational ClearQuest/ClearCase implementation that will be installed
 - d. Develop the requirements management implementation plan and obtain approval from stakeholders
2. Rollout the implementation
 - a. Tool implementation
 - i. Install and configure Rational RequisitePro, ClearQuest, ClearCase, RUP, and UCM
 - ii. Develop necessary reports to satisfy CMMI requirements
 - b. Develop and approve project-specific plans and procedures (for each project)
 - i. Project-specific requirements management plan
 - ii. Project-specific requirements management procedures
 - b. Orientation & Training (for each project)
 - i. Publicize the organizational policy for requirements management to all team members
 - ii. Deliver “body of knowledge” requirements management training to the appropriate project team members
 - iii. Deliver IBM Rational process and tool training to the appropriate project team members
 - iv. Deliver project-specific requirements management implementation training to all project team members
 - b. Project-specific requirements management implementation

- i. Document requirements using Rational RequisitePro and ClearCase
 - ii. Review and approve the requirements before beginning work
 - iii. Setup bi-directional traceability from requirements to project plans and work products using Rational RequisitePro
 - iv.
 - b. Manage and track the requirements management implementation plan
2. Oversee the implementation
 - a. Evaluate the requirements management rollout against the plan
 - b. Manage and track requirements change requests using Rational ClearQuest and RequisitePro
 - c. When requirements change, identify inconsistencies between requirements and project work products, and implement corrective actions
 - d. Evaluate project-specific implementation of requirements management against the project-specific requirements management plan, and organizational guidance
 - i. By the project manager
 - ii. By the quality assurance organization
 - iii. By senior management
 - e. Improve the implementation based on measurements and metrics, project team feedback, and management oversight

Description of the Requirements Management Process

[Note: The use of *italics* indicates material taken directly from the CMMI.]

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.

The RM process area involves the following:

- Develop an understanding with the requirements providers on the meaning of the requirements
- Obtain commitments to the requirements from the project participants
- Manage changes to the requirements as they evolve during the project
- Maintain bi-directional traceability among the requirements and the project plans and work products
- Identify inconsistencies between the project plans and work products and the requirements

Requirements management processes manage all requirements received or generated by the project, including both technical and non-technical requirements as well as those requirements levied on the project by the organization. In particular, if the Requirements Development process area is implemented, its processes will generate product and product-component requirements that will also be managed by the requirements management processes. When the Requirements Management, Requirements Development, and Technical Solution process areas are all implemented, their associated processes may be closed tied and be performed concurrently.

The project takes appropriate steps to ensure that the agreed-upon set of requirements is managed to support the planning and execution needs of the project. When a project receives requirements from an approved requirements provider, the requirements are reviewed with the requirements provider to resolve issues and prevent misunderstanding before the requirements are incorporated into the project's plan. Once the requirements provider and the requirements receiver reach an agreement, commitment to the requirements is obtained from the project participants. The project manages changes to the requirements as they evolve and identifies any inconsistencies that occur among the plans, work products, and requirements.

Part of the management of requirements is to document requirements changes and rationale and maintain bi-directional traceability between source requirements and all product and product-component requirements.

Refer to Figure 5 for a graphical representation of the Requirements Management process area.⁹

⁹ From "CMMI v1.1Tutorial" by Mike Phillips

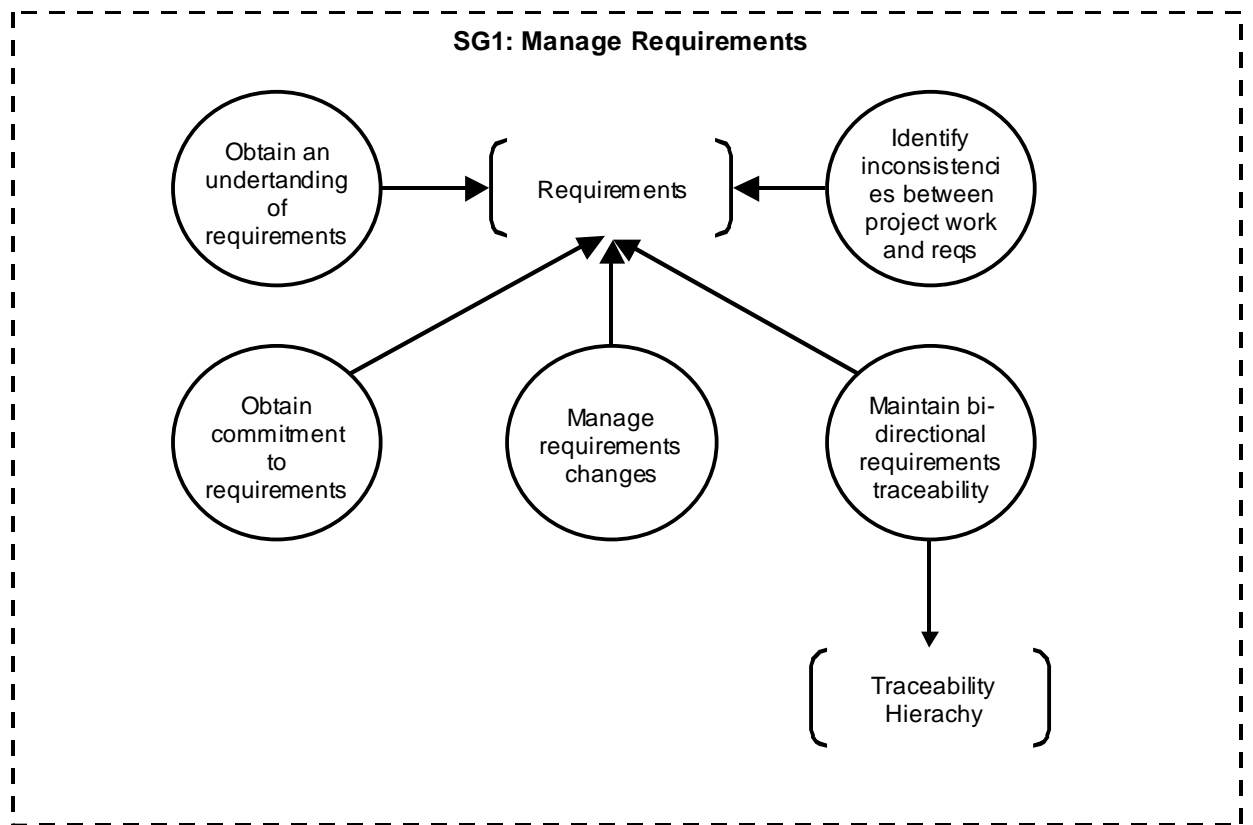


Figure 5: Graphical representation of the Configuration Management process area.

Satisfying the Requirements Management Process Area's Specific Goals and Practices

[Note: The use of *italics* indicates material taken directly from the CMMI.] The Requirements Management process area's specific goals, and the practices that support those goals are:

Specific Goal 1 (SG 1) Requirements are managed and inconsistencies with project plans and work products are identified

The project maintains a current and approved set of requirements over the life of the project by doing the following:

- *Managing all changes to the requirements*
- *Maintaining the relationships between the requirements, the project plans, and the work products*
- *Identifying inconsistencies between the requirements, the project plans and the work products*
- *Taking corrective action*

When followed, the RUP disciplines, Requirements and Project Management, together will satisfy the majority of the practices specified in the Requirements Management process area.

Specific Practice 1.1 (SP 1.1) Develop an understanding with the requirements management providers on the meaning of the requirements

As the project matures and requirements are derived, all activities or disciplines will receive requirements. To avoid requirements creep, criteria are established to designate appropriate channels, or official sources, from which to receive requirements. The receiving activities conduct analyses of the requirements with the requirements provider to ensure that a compatible, shared understanding is reached on the meaning of the requirements. The result of this analysis and dialog is an agreed-to set of requirements.

Typical work products include:

- Lists of criteria for distinguishing appropriate requirements providers
- Criteria for evaluating and acceptance of requirements
- Results of analyses against criteria
- An agreed-to set of requirements

SP 1.1 Implementation Approach

During the Requirements portion of each iteration, primarily during the Inception and Elaboration phases, the project team uses the following RUP Requirements workflows: Understand Stakeholder Needs, Analyze the Problem, Defines the System, Manage the Scope of the System, and Refine the System Definition. The project team documents Stakeholder Requests in the Vision document, and further decomposes these requirements into use-cases, use-case realizations, and supplementary specification. At the end of this process, an understanding of the requirements has been established.

Rational RequisitePro facilitates this interaction by allowing all project team members and stakeholders access to evolving requirements simultaneously. Discussion groups let disparate team members conduct dialog to better resolve inconsistencies and ambiguities.

Specific Practice 1.2 (SP 1.2) Obtain commitments to the requirements from the project participants

Whereas the previous specific practice dealt with reaching an understanding with the requirements providers, this specific practice deals with agreements and commitments among those who have to carry out the activities necessary to implement the requirements. Requirements evolve throughout the project, especially as described by the specific practices of the Requirements Development process area and the Technical Solution process area. As the requirements evolve, this specific practice ensures that project participants commit to the current, approved requirements and the resulting changes in project plans, activities, and work products.

Typical work products include:

- Requirements impact assessments
- Documented commitments to requirements and requirements changes

SP1.2 Implementation Approach

The Requirements discipline “Review Requirements” activity formally requests that the project team and stakeholders review the requirements, and the “Review Record” artifact records the results of the review. RUP provides guidelines on how to perform requirements reviews, and what constitutes a “good and complete” requirements. This interaction is documented in the project’s Requirements Management Plan, which should be reviewed and approved by the various project stakeholders.

Specific Practice 1.3 (SP 1.3) Manage changes to the requirements as they evolve during the project

During the project, requirements change for a variety of reasons. As needs change and as work proceeds, additional requirements are derived and changes may have to be made to the existing requirements. It is essential to manage these additions and changes efficiently and effectively. To effectively analyze the impact of changes, it is necessary that the source of each requirement is known and the rationale for any change is documented. The project manager may, however, want to track appropriate measures of requirements volatility to judge whether new or revised controls are necessary.

Typical work products include:

- Requirements status
- Requirements database
- Requirements decision database

SP 1.3 Implementation Approach

The RUP workflow “Manage Changing Requirements” provides excellent guidance to projects regarding this specific practice. Changes are entered via Rational ClearQuest as change requests, and are reviewed by the project’s Change Control Board (CCB) in the Configuration and Change Management discipline’s “Review Change Request” activity. The project team has the ability to review the requirement during the “Review Requirements” activity. As the requirements changes are approved, the actual requirements and associated work products are modified, and their dependencies/relationships are updated via RUP’s “Manage Dependencies” activity.

This process should be documented in the project’s Requirements Management Plan or Software Configuration Management Plan. To satisfy an appraisal, an organization must show that requirements changes are documented, managed, and controlled, and the project work products are kept consistent with the changed requirements.

Specific Practice 1.4 (SP 1.4) Maintain bi-directional traceability among the requirements and the project plans and work products

The intent of this specific practice is to maintain the bi-directional traceability of requirements for each level of product decomposition. When the requirements are managed well, traceability can be established from the source

requirement to its lower level requirements and from the lower level requirements back to their source. Such bi-directional traceability helps determine that all source requirements have been completely addressed and that all lower level requirements can be traced to a valid source. Requirements traceability can also cover the relationships to other entities such as intermediate and final work products, changes in design documentation, test plans, and work tasks. The traceability should cover both the horizontal and vertical relationships, such as across interfaces. Traceability is particularly needed in conducting the impact assessment of requirements changes on the project plans, activities, and work products.

Typical work products include:

- Requirements traceability matrix
- Requirements tracking system

SP 1.4 Implementation Approach

As shown in Figure 4, the RUP Concept page “Traceability”, describes the traceability philosophy. This philosophy is enacted by RUP’s “Manage Dependencies” activity, and is documented in the project’s Requirements Management Plan.

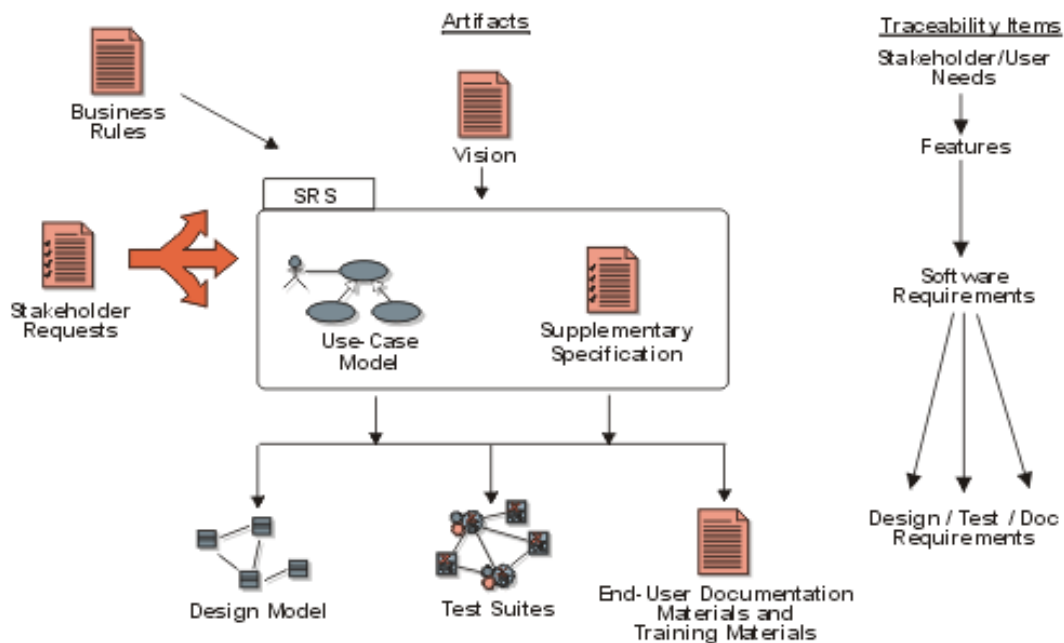


Figure 4

Traceability is established early in the project lifecycle in Rational RequisitePro. RUP’s Tool Mentor, “Manage Dependencies Using Rational RequisitePro” provides RUP/ReqPro users guidance in how to use the tool effectively for this purpose. RequisitePro allows for the configurable definition of various types of project work products, and supports bi-directional traceability between them. As the project progresses, and requirements evolve, this capability becomes very important in supporting the other Requirements Management specific practices

To be compliant with this specific practice, the organization must show that this capability is being used, and kept consistent with changes in requirements. Simply setting up traceability once is not adequate, and doesn’t deliver the real value that consistent use provides.

Specific Practice 1.5 (SP 1.5) Identify inconsistencies between the project plans and work products and those requirements

This specific practice finds the inconsistencies between the requirements and the project plans and work products and initiates the corrective action to fix them.

Typical work products include:

- Documentation of inconsistencies including sources, conditions, and rationale
- Corrective actions

SP 1.4 Implementation Approach

As shown in Figure 4, the Rational Unified Process, used in conjunction with Rational's tools, helps to facilitate the identification and resolution of inconsistencies between requirements and project plans and work products. When RUP is executed properly, members of the software engineering team are able to identify inconsistencies, and raise concerns during project status meetings during the "Monitor Project Status" activity under the Project Management Discipline. When an inconsistency is raised, a change request is entered into ClearQuest, and corrective actions are taken by updating the various project artifacts, models, plans, etc. via the "Manage Dependencies" activity under the Requirements discipline.

Specifically how a project can identify, manage, and handle inconsistencies is documented in the project's Requirements Management Plan. As discussed above, traceability is handled quite effectively with RequisitePro.

This level of requirements management interaction can be quite complex, and it's strongly recommended that the project team is properly trained in the execution of RUP, the use of RequisitePro and ClearQuest, and how specifically these processes and tools are implemented on the project.

To be compliant in this practice, a project must show that inconsistencies between requirements and project plans and work products have been identified, documented, and resolved. This may include the updating of plans, the modification of specifications or code, or the changing of traceability.

Satisfying the Requirements Management Process Area's Generic Goals and Practices

[Note: The use of *italics* indicates material taken directly from the CMMI.] The Requirements Management process area's generic goals, and the practices that support those goals are:

Generic Goal 2 (GG 2) The process is institutionalized as a managed process

This generic goal must be satisfied to reach maturity level 2 in the requirements management process area. The intent of this goal is that a project puts in place, follows, and sustains a set of processes. Satisfying this generic goal shows that an organization has institutionalized the processes for the requirements management process area at maturity level 2.

The generic practices that map to the generic goal includes practices for the project to

- Follow a policy,
- Plan its process and its work,
- Provide resources and assigns responsibility to perform the process and project work,
- Train its personnel on the process, tools, and additional required knowledge for each process area,
- Manage and control project work products and processes,
- Evaluate how well it adheres to the identified process, and
- Review project status with project management and senior management.
-

RUP and Rational tools provide the foundation for a managed process. Rational process flows, roles, responsibilities, templates, oversight, etc. must be reviewed and tailored by the organization and project in order to fulfill their unique needs.

Commitment to Perform Generic Practice 2.1 (GP 2.1 – CO 1) Establish and maintain an organizational policy for planning and performing the requirements management process

This policy establishes organizational expectations for establishing and maintaining requirements, maintaining bi-directional traceability, managing changes to requirements, identifying inconsistencies between requirements and project plans/work products, and applying corrective actions when appropriate.

For each process area, the CMMI requires that a written organizational policy be in place and followed by the organization via the Commitment to Perform common feature. RUP does not specifically address the need for policies (or a single, overarching policy), although the Software Engineering Process Authority (SEPA) described in RUP would be the appropriate entity to help develop the policies. Typically these policies are authorized or signed by a senior level manager in the organization.

An organization must establish, publicize, and maintain a requirements management policy to comply with this generic practice.

Ability to Perform Generic Practice 2.2 (GP 2.2 – AB 1) Establish and maintain the plan for performing the requirements management process

This plan for performing the requirements management process can be included in (or referenced by) the project plan, which is described in the Project Planning process area.

By completing and maintaining RUP's requirements management plan via the template provided, a project satisfies this Ability to Perform generic practice.

The RUP activity that satisfies this generic practice is Requirements->Analyze the Problem->Develop Requirements Management Plan.

Ability to Perform Generic Practice 2.3 (GP 2.3 – AB 2) Provide adequate resources for performing the requirements management process, developing the work products, and providing the services of the process

Examples of resources provided include the following tools:

- Requirements management tools - RequisitePro
- Change management tools - ClearQuest
- Traceability tools - RequisitePro

Organizations can map the required CMMI resources to RUP roles, keeping in mind the CMMI activities those roles are responsible for have to be performed, even if RUP does not address them. Of course, funding must be provided if the roles are to effectively perform their responsibilities. The RUP activity Project Management->Develop

Software Development Plan->Define Project Organization & Staffing is the appropriate place to define and plan for the necessary roles.

RUP calls out several requirements management-related roles including:

- System Analyst
- Requirements Specialist
- Requirements Reviewer
- Project Manager

The RUP activities Set Up Tools and Verify Tool Configuration and Installation under the Environment->Prepare Environment for an Iteration workflow is the appropriate place where the requirements management toolset and environment is installed and configured.

Ability to Perform Generic Practice 2.4 (GP 2.4 – AB 3) Assign responsibility and authority for performing the process, developing the work products, and providing the services of the requirements management process

Similar to the previous Ability to Perform generic practice, the RUP activity Project Management->Develop Software Development Plan->Define Project Organization & Staffing is the appropriate place to assign responsibility and authority for performing the requirements management process.

Ability to Perform Generic Practice 2.5 (GP 2.5 – AB 4) Train the people performing or supporting the requirements management process as needed

Examples of training topics include the following:

- Roles, responsibilities, and authority of the requirements management staff
- Requirements management standards, procedures, and methods
- Requirements management system

This CMMI Ability to Perform common feature requires various roles and groups in the organization to be trained or oriented in requirements management. Informal training/orientation can be provided by the RUP itself. It is Web-based and can be available to all project team members via a Web browser.

Rational University provides many classes and workshops where formal RM process and tool training can be acquired. A large number of books have been published that focus on RUP and the various best practices it advocates. Finally, a number of “body of knowledge” courses and books are available to provide specific guidance to requirements management professionals.

It is important to note that project personnel must be oriented and trained on the project-specific requirements management processes, procedures, and tools.

Directing Implementation Generic Practice 2.6 (GP 2.6 – DI 1) Place designated work products of the requirements management process under appropriate levels of configuration management

Examples of work products placed under configuration management include the following:

- Requirements Management Plan
- Vision Statement
- Stakeholder Requests
- Use-Case Model
- Use-Cases
- Supplementary Specifications
- Change Requests

Like requirements, process specifications must also be managed. By placing the requirements management process descriptions, plans, procedures, policies, and work products under configuration management, this generic practice can be satisfied.

The RUP activities that satisfy this generic practice (assuming the previously identified items are managed) are: “Schedule and Assign Work,” “Make Changes,” and “Deliver Changes.”

Directing Implementation Generic Practice 2.7 (GP 2.7 – DI 2) Identify and involve the relevant stakeholders of the requirements management process as planned

Examples of activities for stakeholder involvement include the following:

- Reviewing and approving requirements
- Assessing the impact of requirements changes
- Approving changes to requirements
- Implementing changes to requirements

To satisfy this generic practice, it is important that the relevant project stakeholders review and approve the project's requirements management plan. By following the "Develop Requirements Management Plan" activity, and obtaining approval, the project will partially satisfy this practice. This practice is intended to be a proactive effort to identify those stakeholders that are directly affected by this process area and overtly planning for their involvement. Typically, the group of relevant stakeholders is much larger than the number of signatories on the RM Plan. Care should be taken to ensure all relevant stakeholders are considered and addressed in the plan, and are involved in RM activities where appropriate.

Directing Implementation Generic Practice 2.8 (GP 2.8 – DI 3) Monitor and control the requirements management process against the plan for performing the process and take appropriate corrective action

Examples of measures used in monitoring and controlling include the following:

- Number of changes to requirements
- Status of requirements

Reviews required by this CMMI Verifying Implementation common feature generic practice can be satisfied by any number of the following RUP reviews:

- Project Approval Review
- Project Planning Review
- Iteration Plan Review
- PRA Project Review
- Iteration Criteria Evaluation Review
- Iteration Acceptance Review
- Lifecycle Milestone Review
- Project Acceptance Review

These project reviews can be accomplished through the Monitor Project Status activity of RUP. This activity requires that the various project team members submit status reports to the project manager.

RUP does not, however, specifically look for requirements management process status against the requirements management plan. To properly satisfy this generic practice, review minutes must show that the requirements management process is monitored and controlled.

Verifying Implementation Generic Practice 2.9 (GP 2.9 – VE 1) Objectively evaluate adherence of the requirements management process against its process description, standards, and procedures, and address noncompliance

Examples of activities reviewed include the following:

- Reviewing and approving requirements
- Tracking and controlling requirements changes
- Maintaining traceability
- Identifying requirements/work product inconsistencies
- Resolving requirements/work product inconsistencies

Examples of work products reviewed include the following:

- Requirements management plan
- Requirements
- Change request database
- Traceability matrix

- Updated project plans and work products due to changed requirements

CMMI-required objective reviews can easily be satisfied by having RUP's "Project Reviewer" role represented at the project status meetings and senior management reviews required by other Verifying Implementation generic practices. It is important for the project to undergo both requirements management process and product reviews by the objective source.

In some cases, a separate review meeting should be held to specifically address the configuration management process area. Generally, these separate reviews are defined in the organization's Quality Assurance plan.

Verifying Implementation Generic Practice 2.10 (GP 2.10 – VE 2) Review the activities, status, and results of the requirements management process with higher level management and resolve issues

Higher-level management reviews can be accommodated by the RUP's PRA project review activity. This review requires that the project's senior management review the project's process activities and milestones. An outcome of this review is the Review Record. The Review Record must reflect that the project's requirements management process and products were reviewed during the activity to satisfy this Verifying Implementation generic practice.

CREDITS

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APPENDIX

CMMI Goal or Practice	Practice Description	RUP Role	RUP Process	RUP Procedure	Tool	Observation/ Recommendation
SG 1	Manage Requirements – Requirements are managed and inconsistencies with project plans and work products are identified					
SP 1.1	Obtain an Understanding of the Requirements – Develop an understanding with the requirements providers on the meaning of the requirements	System Analyst	Requirements Discipline Workflow Detail: Understand Stakeholder Needs Concepts: Requirements Management	Activity: Review Requirements Activity: Elicit Stakeholder Requests Artifact: Stakeholder Requests Artifact: Use-Case Model	ReqPro	Obs: RUP allows for both the identification and management of different levels of system and software requirements. The RM Plan template and RequisitePro's capabilities provide ways to describe the RM work the project performs, and a location to document requirements. Rec: The project needs to document its tailored RUP RM process, be trained on it, and use those adopted processes and artifacts
SP 1.2	Commitment to Requirements – Obtain commitment to the requirements from the project participants	Project Manager System Analyst	Requirements Discipline Workflow Detail: Manage the Scope of the System Guidelines: Important Decisions in Requirements	Develop Vision Activity: Review Change Request Guidelines: Requirements Management Plan	ReqPro	Obs: RUP activities provide for interaction between the client, the system analyst and project team, and other stakeholders. Rec: The project needs to document its tailored RUP RM process, be trained on it, and use those adopted processes and artifacts.
SP1.3	Manage Requirements Changes – Manage changes to the requirements as they evolve during the project	System Analyst Requirements Reviewer	Workflow Detail: Manage the scope of the system Workflow Detail: Manage Requirements	Artifact: Software Requirements Specification Artifact: Requirements Attributes Artifact: Change Request	ClearQuest ClearCase ReqPro	Obs: RUP provides for the management of requirements changes throughout the lifecycle. Changes are covered in numerous activities and artifacts. Rec: The project team must use the processes and artifacts as defined in RUP.

CMMI Goal or Practice	Practice Description	RUP Role	RUP Process	RUP Procedure	Tool	Observation/ Recommendation
SP1.4	Maintain Bi-directional Traceability of Requirements – Maintain bi-directional traceability among the requirements and the project plans and work products	System Analyst Requirements Reviewer	Workflow Detail: Understand Stakeholder Needs Workflow Detail: Manage the Scope of the System Workflow Detail: Manage Changing Requirements Concepts: Traceability	Activity: Develop RM Plan Activity: Manage Dependencies Artifact: Requirements Management Plan Artifact: Requirements Attributes Tool Mentor: Managing Dependencies Using ReqPro	ReqPro	Obs: RUP provides for the documentation of requirements attributes in the Requirements Management Plan. RequisitePro is then used to capture requirements, their attributes, and the traceability among requirements and to project plans and work products. Rec: The project must complete the RM Plan, describe the traceability strategy, and then implement this strategy.
SP1.5	Identify Inconsistencies Between Project Work and Requirements – Identify inconsistencies between the project plans and work products and the requirements	Requirements Specifier System Analyst Software Architect Designer	Discipline: Requirement Discipline: Analysis and Design	Activity: Detail a Use-Case Activity: Detail the Software Requirements Activity: Use-Case Analysis Activity: Use-Case Realization Activity: Subsystem Design Artifact: Use-Case Model Artifact: Design Model	ReqPro	Obs: The requirements drive the development effort through Use Cases, which are realized by the Design Model, which is implemented by the Implementation Model, which is verified by the Design Model. These relationships should be visible through the ReqPro traceability matrix. Rec: As the interactions are deeply imbedded in RUP and ReqPro, project training in this area should be formal, versus other methods like OJT or mentoring.
GG 1	Institutionalize a Managed Process - The process is institutionalized as a managed process					

CMMI Goal or Practice	Practice Description	RUP Role	RUP Process	RUP Procedure	Tool	Observation/ Recommendation
GP 2.1 CO 1	Establish an Organizational Policy - Establish and maintain an organizational policy for planning and performing the requirements management process	Senior Management Software Engineering Process Authority (SEPA)				Obs: RUP does not provide for the creation of a policy as defined by the CMMI. Rec: The organization's senior management is responsible for creating software engineering policies. RUP Refers to the concept of the software engineering process authority (SEPA) that might drive/maintain policies. To satisfy this practice, these policies must be written, publicized, and followed.
GP 2.2 AB 1	Plan the Process - Establish and maintain the plan for performing the requirements management process	Project Manager	Requirements	Activity: Write RM Plan Template: RM Plan		Obs: RUP provides for the creation of a project requirements management plan. Project personnel will be required to provide the critical thinking and actually enter the data into the supplied template. Rec: Complete the RUP-supplied RM Plan, and create a schedule for the project RM tasks.
GP 2.3 AB 2	Provide Resources - Provide adequate resources for performing the requirements management process, developing work products, and providing the services of the process	Project Manager Tool Specialist	Project Management, Develop Software Development Plan Environment, Prepare Environment for Project	Activity: Define Project Organization and Staffing Activity: Select and Acquire Tools Activity: Schedule and Assign Work		Obs: RUP has several processes that together provide for allocating resources against the requirements management tasks and deliverables of a work breakdown structure. Rec: Document the necessary resources in the project's SDP or RM Plan.
GP 2.4 AB 3	Assign Responsibility - Assign responsibility and authority for performing the services of the requirements management process	Project Manager	Project Management, Develop Software Development Plan	Activity: Define Project Organization and Staffing Activity: Acquire Staff		Obs: RUP has several processes that together provide for allocating resources against the requirements management tasks and deliverables of a work breakdown structure. Rec: Document the roles and responsibilities in the project's SDP or RM Plan.

CMMI Goal or Practice	Practice Description	RUP Role	RUP Process	RUP Procedure	Tool	Observation/ Recommendation
GP 2.5 AB 4	Train People - Train the people performing or supporting the requirements management process as needed	Project Manager	Project Management, Manage Iteration	Activity: Acquire Staff		<p>Obs: Rational University provides training that more than adequately covers tools (ClearCase, ClearQuest, ReqPro) and process (RUP, Requirements Management with Use-Cases - RMUC).</p> <p>Rec: RM practitioners would be required to obtain RM body of knowledge training above and beyond the training available from IBM Rational. Also, team members require training on the project's specific RM environment/processes/procedures.</p>
GP 2.6 DI 1	Manage Configurations - Place designated work products of the requirements management process under appropriate levels of configuration management	Project Manager Any Role	Project Management, Monitor & Control Project Configuration and Change Management, Change and Deliver Configuration Items	Activity: Schedule & Assign Work Activity: Make Changes Activity: Deliver Changes Template: SCMP	ClearCase ClearQuest	<p>Obs: The process exists in RUP that, when followed by the project, provides for the placing of requirements management work products under control.</p> <p>Rec: Project personnel must define what appropriate requirements management work products to control, and show evidence they are being controlled.</p>
GP 2.7 DI 2	Identify and Involve Relevant Stakeholders - Identify and involve the relevant stakeholders of the requirements management process as planned	Project Manager	Discipline: Project Management Discipline: Requirements	Activity: Develop Development Case Activity: Identify Stakeholders Artifact: RM Plan		<p>Obs: While RUP indicates that projects should identify stakeholders, more detail on which project stakeholders should be integrated into the RM process must be documented.</p> <p>Rec: The project must identify the requirements management stakeholders, and have them review and approve the RM Plan and requirements. The stakeholders also need to show involvement throughout the project.</p>

CMMI Goal or Practice	Practice Description	RUP Role	RUP Process	RUP Procedure	Tool	Observation/ Recommendation
GP 2.8 DI 3	Monitor and Control the Process - Monitor and control the requirements management process against the plan for performing the process and take appropriate corrective action	Project Manager	Project Management, Monitor and Control Project	Activity: Monitor Project Status		<p>Obs: The Monitor Project Status activity allows for product monitoring, but lacks specific RM process monitoring guidance.</p> <p>Rec: Need to ensure that requirements management activities are monitored during the Monitor Project Status activity, and that the meeting's minutes reflect the review. The project manager must create an appropriate schedule with identified RM tasks and resources (from the RM Plan), and then review the schedule against actual project activities.</p>
GP 2.9 VE 1	Objectively Evaluate Adherence - Objectively evaluate adherence of the requirements management process against its process description, standards, and procedures, and address noncompliance	Project Manager	Project Management, Monitor and Control Project	Activity: Monitor Project Status		<p>Obs: RUP and the supplied SQAP template tend to concentrate on the product reviews/audits, with little on how the process is evaluated.</p> <p>Rec: Need to ensure that requirements management activities are monitored by the SQA group during the Monitor Project Status activity, and that minutes of these reviews and audits are created.</p>
GP 2.10 VE 2	Review Status with Higher Level Management - Review the activities, status, and results of the requirements management process with higher level management and resolve issues	Project Review Authority (PRA)	Project Management, Monitor and Control Project	Activity: Project Review Authority (PRA) Project Review		<p>Obs: The PRA Project Review activity allows for product monitoring, but lacks specific process monitoring guidance.</p> <p>Rec: Need to ensure that software requirements management activities are reviewed during the PRA Project Review, and that the minutes reflect the process review.</p>

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