Capability Maturity Model®-Integrated-Systems/Software Engineering

CMMI℠-SE/SW

Continuous Representation – Volume I
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FOR THE COMMANDER

Norton L. Compton, Lt Col., USAF
SEI Joint Program Office

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PART 1

Preface

The Capability Maturity Model® [1] Integration (CMMI SM[2]) project involved a large number of people from different organizations throughout the world. These organizations were using one or more CMMs® and were interested in the benefits of developing an integration framework to aid in enterprise-wide improvement and integration activities.

This project work was sponsored by the U.S. Department of Defense (DoD), specifically the Office of the Secretary of Defense, Acquisition and Technology (OSD/A&T). Organizations from industry and government, and the Software Engineering Institute (SEI) joined together to develop the CMMI Framework, CMMI models, and supporting products. These organizations donated the time of one or more of their people to participate in the CMMI project.

About This Model

The development of this model has involved more than simply adding existing model materials together. Using processes that promote consensus, the CMMI product development team has built a framework that accommodates multiple disciplines and is flexible enough to support two different representations (staged and continuous).

Using information from popular and well-regarded models as source material, the product development team has created usable and cohesive integrated models that can satisfy those currently using other CMMs as well as those new to the CMMI concept.

The CMMI project team has been working to provide systems engineering and software engineering guidance that encourages process improvement in organizations of any structure.

Since 1991, CMMs have been developed for a myriad of disciplines. Some of the most notable include models for systems engineering, software engineering, software acquisition, workforce practices, and integrated product and process development.

[1] ® Capability Maturity Model is registered in the U.S. Patent and Trademark Office.
[2] SM CMMI is a service mark of Carnegie Mellon University.

Although these models have proven useful to many organizations, the use of multiple models has been problematic. Many organizations would like to focus their improvement efforts across the disciplines within their organizations; however, the differences among these discipline-specific models, including their architecture, content, and approach, has limited these organizations' ability to focus their improvement successfully. Further, applying multiple unintegrated models within and across an organization becomes more costly in terms of training, assessments, and improvement activities. A model that successfully integrates disciplines and has integrated training and assessment support, would address these problems.

The CMM Integration project was formed to disentangle the problem of using multiple CMMs. The mission of the project was to combine three source models—(1) SW-CMM v2.0 draft C, (2) EIA/IS 731, and (3) IPD-CMM v0.9a—into a single model for use by organizations pursuing enterprise-wide process improvement.

The team's mission also included the development of a common framework for supporting the future integration of other discipline-specific CMMI models. Also included in the team's mission was the goal of ensuring all of the products developed were compliant with the ISO 15504 standard for software process assessment.

Acknowledgements

Many talented people were involved in developing the CMMI Product Suite. Three primary groups involved in this development were the steering group, product development team, and stakeholder/reviewers.

The steering group guided and approved the plans of the product development team, provided consultation on significant CMMI project issues, and ensured involvement from a variety of interested communities.

The product development team wrote, reviewed, revised, discussed, and agreed on the structure and content of the CMMI Product Suite, including the model, training, and assessment materials. All development activities were based on an A-Specification provided by the steering group, the three source models, and comments from stakeholder and steering group members.

The stakeholders/reviewers reviewed pre-release versions of CMMI products and provided comments to the product development team.

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- Bob Rassa, Raytheon Systems Company (co-chair)
- Rich Aggers, Office of the Secretary of Defense
- Clyde Chittister, Software Engineering Institute
- Michael Devine, US Army
- Joe Farinello, Electronic Systems Center
- Linda Ibrahim, Federal Aviation Administration
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- David McConnell, US Navy, Naval Surface Warfare Center
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- Dan Nash, Raytheon Systems Company
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- Richard Waina, EDS Inc.
- George Yamamura, Boeing-ISDS
- James Yeats, General Dynamics Land Systems

Feedback Information

The CMMI product development team is not only responsible for creating CMMI products, they are also very interested in your ideas for improving these products. Whether you are part of the systems development community, software development community, or an executive looking toward the future, you can help these products continually improve.

See the CMMI Web site for information on how to provide feedback: http://www.sei.cmu.edu/cmm/cmms/cmms.integration.html

395 If you have questions, send an email to cmmi-comments@sei.cmu.edu.

1 Introduction

A model is a simplified representation of the real world. Capability Maturity Models (CMMs) contain the essential elements of effective processes for a particular discipline. These elements are based on the concepts developed by Crosby, Deming, Juran, and Humphrey [Crosby 79, Juran 88, Deming 86, Humphrey 89]. CMMI models contain the essential elements of effective processes for one or more disciplines.

Purpose and Scope

Process is a leverage point for any organization's sustained improvement. The purpose of this CMMI model is to provide guidance for improving your organization's processes and your ability to manage the development and maintenance of products or services. This model places proven practices into a structure that helps your organization assess its process improvement status, establish priorities for improvement, and implement these improvements.

All CMMI models contain common elements that can be used to improve processes used for developing and maintaining products or services. However, CMMI models also have elements that are designed to meet the needs of specific disciplines. This model is designed specifically for organizations interested in improving processes in both systems engineering and software engineering disciplines.

Your organization can use this model to help set process improvement goals and priorities, improve processes, and provide guidance for ensuring quality processes. CMMI models can serve as a guide for self-improvement.

Audience

Whether your organization is familiar with CMMs or not, this CMMI model can help you implement process improvement in your organization. For those who currently use one of the source models for the CMMI Product Suite (SW-CMM, EIA/IS 731, IPD-CMM), the product development team has designed this model so that your transition to it will be as cost effective and non-disruptive as possible. For those who are unfamiliar with CMMs, the product development team has included all of the information necessary for you to use this model without CMM-specific knowledge.

Read the Overview to get a sense of what is in the CMMI models and how to interpret and use the information in them. If you cannot read the Overview, use Table 1 to determine the minimum set of sections you should read before using the model:

Audience Type	Minimum Set of Sections
Familiar with using CMMs	Preface Introduction: Purpose and Scope Structure of the Model Understanding the Model Using the Model: Transition From Legacy Models Generic Practices Volume I Glossary
Unfamiliar with using CMMs	Foreword Preface Introduction Structure of the Model Understanding the Model Using the Model Generic Practices Volume II

Table 1: Recommended Reading by Audience Type

Organization

There are two main volumes that comprise each representation of the CMMI model: Volume I and Volume II.

Volume I

Volume I consists of the two parts described below, including twenty-four process areas, their goals and practices. (See Structure of the Model for more information about the model elements within each process area.)

Part 1 consists of seven sections:

The Overview has four chapters that describe the model components and that help you understand and use the model:

- The Introduction (this section) offers a broad view of the model, why it exists, who it is for, and where it came from.
- Structure of the Model describes the components of the model, including levels, goals, and practices.
- Understanding the Model provides insight into the meaning of the model for your organization.
- Using the Model explains the ways in which your organization can use the model.

The Generic Practices describe the generic goals and practices, which ensure that implementing process areas is effective, repeatable, and lasting.

The Normative Model contains the process areas, and their goals and practices.

The References contain information you can use to locate the sources used to create the materials in the CMMI Product Suite.

The Acronym List defines acronyms used in the CMMI models.

The Glossary defines terms used in the CMMI Product Suite that are not adequately defined in the context of this model by a common American English dictionary.

The Tailoring Criteria define the ways in which the model can be tailored to meet the needs of individual organizations.

Part 2 consists of the Assessment Requirements for CMMI.

Volume II

Volume II consists of the two parts described below, including the same twenty-four process areas as in Volume 1. Each process area contains goals, practices, typical work products, notes, and other informative elements. (See Structure of the Model for more information about the model elements within each process area.)

Part 1 consists of eight sections:

The Overview has four chapters that describe the model components and that help you understand and use the model:

The Generic Practices describe the generic goals and practices, which ensure that implementing process areas is effective, repeatable, and lasting.

The Normative Model contains the process areas, and their goals and practices.

The Informative Model contains the process areas, and all normative and informative components of the model, including goals, practices, subpractices, typical work products, notes, examples, etc.

The References contain information you can use to locate the sources used to create the materials in the CMMI Product Suite.

The Acronym List defines acronyms used in the CMMI models.

The Glossary defines terms used in the CMMI Product Suite that are not adequately defined in the context of this model by a common American English dictionary.

The Tailoring Criteria define the ways in which the model can be tailored to meet the needs of individual organizations.

Background

In 1991, the Software Engineering Institute published the Capability Maturity Model for Software (SW-CMM). This model was based on principles of product quality that have existed for the last 60 years. In the 1930s, Walter Shewart promulgated the principles of statistical quality control. His principles were further developed and successfully demonstrated in the work of W. Edwards Deming [Deming 86] and Joseph Juran [Juran 88, Juran 89]. These principles were adapted by the SEI into a maturity framework that established a project management and engineering foundation for quantitative control of the software process.

Since then, not only has that model significantly influenced software process improvement worldwide, but also models have been published for other disciplines, including systems engineering, software acquisition, human resource management, and integrated product and process development.

The proliferation of these models has had both positive and negative consequences. Some positive consequences are that the impact of process improvement has been felt in multiple disciplines and has helped organizations to build better products.

Some negative consequences are that some of these models overlap, their differences make them difficult and expensive to use concurrently, they sometimes contradict each other, and information is presented at different levels of detail.

To respond to the negative consequences created by this situation, the CMM Integration project was initiated. Experts from a variety of backgrounds and organizations were tasked to establish a framework that could accommodate current and future models, thereby making enterprise-wide improvement achievable.

Further, the project was tasked to build an initial set of integrated models that covered three disciplines: (1) software engineering, (2) systems engineering, and (3) integrated product and process development. Existing models chosen to be used as the primary sources for the initial set of CMMI models were (1) SW-CMM v2.0 draft C, (2) EIA/IS 731, and (3) IPD-CMM v0.9a.

Integration Benefits of Using CMMI Models

All CMMI models will be designed so that they may be integrated with one another. Therefore, using a model developed within the CMMI Framework has the following benefits:

- Process improvement can be implemented up to and including the enterprise level.
- Inconsistencies and discrepancies across previous models will be resolved.
- Both a continuous and staged representation are supported, so you can use the representation that you prefer.
- Your single-discipline process improvement efforts can be combined with those of other disciplines.
- CMMI-based assessments will harmonize with your organization's previous assessment ratings and thus will protect your current investment.
- Cost savings are likely, especially when pursuing multi-discipline process improvement, and associated training and assessment.
- Communication is encouraged between disciplines in your organization.

Business Performance Benefits of Using CMMI Models

Studies documenting the use of the SW-CMM and the results of process improvement have demonstrated that there can be a significant impact to an organization's bottom line. The following benefits are also expected from use of the CMMI models: [Herbsleb 97, Paulk 98]

- Increased predictability of project costs and schedules
- Higher quality and productivity
- Shorter cycle time
- Increased customer satisfaction
- Higher employee morale

2 Structure of the Model

There are two representations of the CMMI models: staged and continuous. You have chosen the continuous representation. The components of this model are process areas, specific goals, specific practices, generic goals, generic practices, capability levels, capability profiles, target staging, and equivalent staging.

In this chapter, we describe each component of the model you've chosen and the relationships between them. Most of the components described here are also part of CMMI models with a staged representation.

Structural Overview

CMMI models are used to support and guide process improvement activities in an organization. The continuous representation of each CMMI model consists of the major components illustrated in Figure 1.

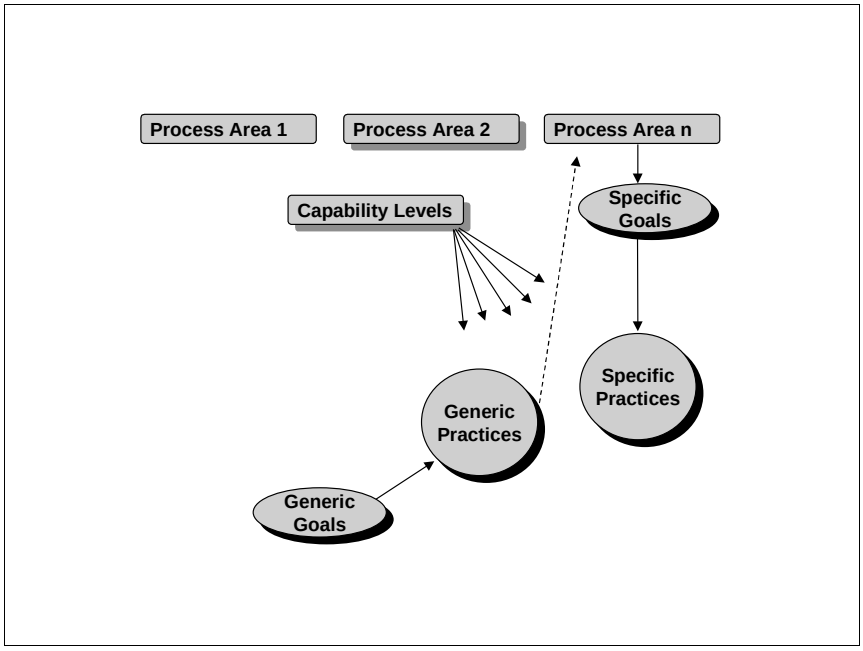

Figure 1: CMMI Model Components

In the continuous representation of a CMMI model, the main organizing components are called process areas. Within each process area there are specific goals and specific practices. The specific practices provide you with guidance on what to implement to help you achieve the specific goals of the process area.

Generic goals and generic practices, which apply to multiple process areas, are included by reference. These practices provide guidance to help you achieve the generic goals.

As you achieve the generic and specific goals for a process area, you are increasing your process capability and reaping the benefits of process improvement.

Required, Expected, and Informative

All components of a CMMI model can be grouped into three categories:

- Required components are essential to achieving process improvement in a given process area. They are used in assessments to determine process capability. Specific goals are required model components that should be achieved by planned and implemented processes.
- Expected components explain what must be done to cover the scope of the process and its goals. They are meant to guide model users and to help assessors. Specific practices are expected model components, whereas subpractices and typical work products are not. Either the practices or acceptable alternatives to them are required in the planned and implemented processes before goals can be considered satisfied.
- Informative components help provide details about the model. Subpractices, typical work products, notes, amplifications, and elaborations are informative model components that help model users understand the goals and practices and how they typically can be achieved.

When you implement a CMMI model, you plan and use processes that conform to the required and expected components of process areas. Conformance with a process area means that in the planned and implemented processes there is an associated process that carries out either the specific practices of the process area, or alternatives that accomplish a result that meets the goal associated with that specific practice.

Capability Dimension

The capability dimension of this model focuses on building the organization's capacity and ability to pursue process improvement in multiple areas. This dimension enables you to track, evaluate, and demonstrate your organization's progress as you improve processes associated with process areas.

Generic Practices

Generic practices are described in the model, but not in the process areas. They are practices that apply to all process areas because they improve process or integration capability. These generic practices have capability levels ranging from 1 to 5 and are expected components in the model.

Some generic practices specify a condition that ensures that the associated process is successful (e.g., "An organizational policy for performing the process should exist"). Others specify an activity to be performed.

Generic practices may be dependent on certain process areas in two ways.

- Some generic practices rely on the support of a process area. An example is the generic practice "place work products under configuration management." This generic practice is supported by the Configuration Management process area.
- Other generic practices cannot be executed without an output from a process area. An example is the generic practice "tailor the process from the organizational set of processes." This generic practice requires the process assets created by the Organizational Process Definition process area.

Generic Goals

A generic goal is defined for each capability level. Each goal expresses what the generic practices of the capability level are trying to accomplish. Each generic practice in a capability level maps to one or more of these goals.

Capability Levels

CMMI models are designed to describe discrete levels of process improvement. Capability levels provide a recommended order for approaching process improvement within a single process area.

All continuous representations of CMMI models reflect capability levels in their design and content. A capability level consists of related specific and generic practices for a process area that, when performed, achieve a set of goals that increase the maturity of the process and enhance the organization's process capability.

There are six capability levels, designated by the numbers 0 through 5. Capability levels are measured by the achievement of the specific and generic goals that apply to a process area. For example, an organization can reach capability level n of a process area when the generic goals up through capability level n are achieved within the process area, and when specific goals (and associated specific practices up through capability level n) are satisfied in the process. A process area that does not satisfy all of the requirements for capability level 1 is said to be at level 0.

The generic practices and certain process areas upon which they depend create a sequence of capability levels, which engender certain improvements in the implementation and effectiveness of the processes. The characteristics of these levels are described below.

Capability Level 0: Not Performed

A process that is not performed is incomplete because not all of the specific practices are performed.

Capability Level 1: Performed

A performed process is a process that implements and performs all of the capability level 1 specific and generic practices. Since most of the generic practices which require planning, monitoring, and controlling the process performance are at capability level 2, the performance may not be stable and may not meet specific objectives such as quality, cost, and schedule.

Capability Level 2: Managed

A capability level 2 process is a managed process that is planned, performed, monitored, and controlled for individual projects, groups, or standalone processes to achieve a given purpose. Managing the process achieves both the specific goals for the process as well as other goals, such as cost, schedule, and quality. These other goals may differ from one performance of the process to another; unlike the specific goals that are constant from one performance of the process to another.

A managed process is institutionalized by doing the following:

- Adhering to organizational policies
- Following a documented plan and process description

- Having adequate resources (including funding, people, and tools)
- Maintaining appropriate assignment of responsibility and authority over the life cycle
- Training the affected people
- Placing work products under appropriate levels of configuration management
- Measuring the process, its work products, and its services
- Monitoring and controlling the performance of the process
- Objectively reviewing the process, its work products, and its services, and addressing non-compliance
- Reviewing the activities, status, and results of the process with appropriate levels of management, and taking corrective action

The discipline of a managed process ensures that existing practices are retained during times of stress. When these practices are reused on similar efforts, similar results can be expected.

The status of work products and delivery of services are visible to management at defined points (for example, at major milestones and completion of major tasks). Commitments are established with those performing the work and those affected by it. These commitments are revised as needed and satisfied when promised. Work products are controlled, are reviewed with stakeholders, and satisfy their specified requirements, standards, and objectives.

Capability Level 3: Defined

A capability level 3 process is a defined process. A defined process is a managed process that is tailored from the organization's set of standard processes. Deviations beyond those allowed by the tailoring guidelines are documented, justified, reviewed, and approved. A defined process clearly states the following:

- Inputs
- Entry criteria
- Activities
- Roles
- Measures
- Verification steps
- Outputs
- Exit criteria

The in-use process [3] is performed according to the defined process. Selected work products of the defined process are inspected.

The organization's set of standard processes, which are the basis of the defined process, are established and improved over time. These standard processes describe the fundamental process elements that are expected to be incorporated into the defined processes. They also describe the relationships (e.g., ordering and interfaces) between these process elements. The infrastructure to support current and future use of the organization's set of standard processes is also established and improved over time.

Capability Level 4: Quantitatively Managed

A capability level 4 process is a quantitatively managed process. A quantitatively managed process is a defined process that is controlled using statistical and other quantitative techniques. Product quality, service quality, and process performance are understood in statistical terms and are controlled throughout the life cycle.

Quantitative goals for product quality, service quality, and process performance are established and used in managing the process. These quality goals are based on the needs of the customers, end-users, and organization. The people performing the process are directly involved in quantitatively managing the process.

For selected subprocesses, detailed measures of the process performance are collected and statistically analyzed to stabilize process performance. Special causes of process variation are identified and addressed. Product quality, service quality, and process performance measures are incorporated into the organization's process assets to support future fact-based decision-making.

The term "quantitatively managed" implies using appropriate statistical and other quantitative techniques to manage the performance of a process. Managing the performance of a process includes the following:

- Measuring product and process attributes that are important contributors to product quality, service quality, and process performance
- Identifying and addressing special causes of variations in process performance
- Bringing the performance of the process within its observed bounds (that is, making the process performance stable and predictable)·
- Determining the capability of the process to satisfy established product quality, service quality, and process performance goals

[3] The in-use process includes the development and maintenance of the work products and delivery of services.

Taking appropriate corrective actions when the established product quality, service quality, and process performance goals are not satisfied

Capability Level 5: Optimizing

A capability level 5 process is an optimizing process. An optimizing process is a quantitatively managed process that is improved based on an understanding of the common causes *40002* of process variation inherent in the process. An optimizing process focuses on continually improving the range of process performance through both incremental and innovative improvements. Both the defined processes and the organization's set of standard processes are targets of the improvement activities.

Quantitative process improvement goals for the organization are established and continually revised to reflect changing business objectives. Process and technology improvements to address common causes of process variation and measurably improve the planned and in-use 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 goals versus the cost to the organization.

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

Selected technology and process improvements are deployed into the organization systematically. The effects of the deployed technology and process improvements are measured and evaluated against the quantitative process improvement goals.

Capability Level Profiles

A capability level profile is a list of process areas and their corresponding capability levels. The profile may be an achievement profile when it represents the organization's progress for each process area while climbing up the capability levels. Or, the profile may be a target profile when it represents a goal of process improvement. An achievement profile when compared with a target profile enables you not only to track your process-improvement progress, but also enables you to demonstrate your progress to management. Maintaining capability level profiles throughout the process improvement life cycle is both wise and necessary.

Process Dimension

The process dimension of this model focuses on best practices your organization can use to improve processes in particular areas. Before you begin using a CMMI model for improving processes, you must understand the importance of mapping your processes to CMMI process areas. This mapping activity enables you to control process improvement in your organization and to determine your organization's conformance to the CMMI model.

The elements of the process dimension include process areas, specific goals, specific practices, subpractices, typical work products, amplifications, elaborations, and notes.

Process Areas

Process areas are clusters of related practices that are performed collectively to achieve a set of goals. Examples include Configuration Management, Project Planning, and Risk Management. Process areas are the major building blocks you use to establish the process capability of your organization. A process area's activities are described by "specific practices" and are summarized by "specific goals.

A process area is not a process description; it doesn't describe entrance and exit criteria, roles of participants, or resources. A process area describes the details of an effective organization's process, including what it does (specific practices) and why it is done (specific goals). Some CMMI process areas are common to all CMMI models.

Specific Goals

A specific goal is what organizations should be working to achieve in a process area. Specific goals are required model elements and are used in assessments to determine whether a process area is satisfied.

A goal summarizes one or more practices. Whether the organization satisfies the requirements of a process area is determined by investigating whether the associated goals are satisfied.

Specific goals are not assigned to capability levels, specific practices are. Specific practices that support a goal are mapped to it. There can be specific practices at different capability levels mapped to the same goal. However, every goal has at least one capability level 1 practice (i.e., base practice) mapped to it. Higher-level practices meet the goal in an advanced way. The exact meaning of a goal for a given capability level is determined by the specific practices at and below that capability level.

Specific Practices

A specific practice is an activity that is considered important in achieving the specific goals of a process area. They describe what is expected from achievement of the specific goals of a process area. A specific practice is associated with a capability level. Most specific practices are at capability level 1, which means that most specific practices are essential to their process area.

Some specific practices are at a capability level higher than 1. Only when an organization is striving for a higher level of process capability does it consider a higher-level specific practice. For example, within the Decision Analysis and Resolution process area, "considering alternatives when making a decision" is a capability level 1 specific practice, whereas "capturing the rationale for decisions" is a capability level 2 specific practice.

Subpractices

Subpractices are suggested courses of action that correspond to specific practices.

Notes

Notes can appear after many model components. Notes provide the details, whys, and wherefores that help you understand the core information of the model.

Discipline Amplifications

Discipline amplifications contain information that is relevant to a particular discipline. For example, in the CMMI-SE/SW model, you may find discipline amplifications for Software Engineering and Systems Engineering. These bits of information are scattered throughout the model and are labelled "For Software Engineering" or "For Systems Engineering." As the models incorporate more disciplines, other types of discipline amplifications will appear.

Generic Practice Elaborations

In addition, generic practices will be elaborated, as appropriate, to explain how to apply that generic practice in the context of the process area. For example, when the generic practice “Train the people performing or supporting the planned process as needed” is incorporated into the Configuration Management process area, the specific kinds of training for doing configuration management would be described.

References

References are pointers to other components of the model that can perform services for a process area or provide information to the user. Typical phrases expressing these pointers are "Use the Decision and Analysis and Resolution process area for determining the best integration strategy." or "Refer to the Project Planning process area for more information on global project planning." The first form directs that the practices of another process area be used to perform a needed service for the current process area. The second form merely refers the user to additional or more detailed information in another process area. All references are also identifiable in the model because they always appear in italics.

Staging and Maturity Levels

As described earlier in this chapter, an achievement profile represents the current capability levels of the process areas. A target profile represents the goal of process improvement.

Target Staging

A target staging is a sequence of target profiles that describe the path of process improvement to be followed by the organization. This target staging must meet two requirements: It must be (1) monotone increasing and (2) admissible. These requirements are described in more detail in Tailoring Criteria

Equivalent Staging

Equivalent staging is a target staging that is equivalent to the maturity levels of the staged representation. Such staging permits benchmarking of progress between organizations, enterprises, and projects.

Figure 2 shows the target profiles that must be achieved when using the continuous representation to be equivalent to a maturity level when using a staged representation.
The columns of the figure have the following meanings:

- Category is the category to which the process area is assigned.
- Name is the full name of the process area.
- ML is the maturity level assignment of the process area in the staged representation.
- CL1, CL2, CL3, CL4, CL5 are headings for the columns assigned to a capability level in the continuous representation

The shaded areas in the capability level columns indicate target profiles that are equivalent to maturity levels in the staged representation. Examples of these are as follows:

- To achieve Target Profile 2 the first eight process areas (Requirements Management to Supplier Agreement Management) must have satisfied Capability Levels 1 and 2.
- To achieve Target Profile 4 the first twenty-one process areas (Requirements Management to Quantitative Management of Quality and Process) must have satisfied Capability Levels 1, 2, and 3.
- To achieve Target Profile 5 all of the process areas must have satisfied Capability Levels 1, 2, and 3.

Category	Name	ML	CL1	CL2	CL3	CL4	CL5
Engr	Requirements Management	2					
Proj Mgt	Measurement and Analysis	2					
Proj Mgt	Project Monitoring and Control	2					
Proj Mgt	Project Planning	2					
Proj Mgt	Process and Product Quality Assurance	2	Target Profile 2				
Sup	Configuration Management	2					
Sup	Data Management	2					
Proj Mgt	Supplier Agreement Management	2					
Engr	Customer and Product Requirements	3					
Engr	Decision Analysis and Resolution	3					
Engr	Product Integration	3					
Engr	Product Verification	3					
Engr	Technical Solution	3					
Engr	Validation	3		Target Profile 3			
Proc Mgt	Organizational Process Definition	3					
Proc Mgt	Organizational Process Focus	3					
Proj/Proc Mgt	Integrated Project Management	3					
Proj Mgt	Risk Management	3					
Proc Mgt	Organizational Training	3					
Proc Mgt	Organizational Process Performance	4					
Proc Mgt	Organizational Process Technology Improvement	4		Target Profile 4			
Proc Mgt	Quantitative Management of Quality and Process	4					
Proc Mgt	Process Innovation Deployment	5		Target Profile 5			
Proc Mgt	Causal Analysis and Resolution	5					
			Note: Target Profile N is equivalent to Maturity Level N in the staged representation.				

Figure 2: Target Profiles

It may seem strange that no process area is required to attain Capability Levels 4 and 5. The reason is that the Maturity Level 4 process areas operate on selection of subprocesses to be stabilized and quantitatively understood, based on business objectives of the organization. Therefore, no process area is required by the model to reach above capability level 3. Users of the continuous model will probably want to extend their target profiles above Capability Level 3. This extension is assessable if a valid mapping of subprocesses to process areas has been constructed, so that one can tell if for example a process area has been placed under quantitative management.

3 Understanding the Model

The CMMI models apply process management and quality improvement concepts to product development and maintenance using a common-sense approach. The CMMI Product Suite represents a consensus-based approach to identifying and describing good engineering and management practices in a variety of disciplines. Since this model is a simplified representation of the real world, you must reasonably interpret the CMMI practices when you apply them to your organization.

Professional Judgment and CMMI Models

Use professional judgment to interpret CMMI practices. Although process areas depict behavior that should be exhibited in any organization, practices must be interpreted using an in-depth knowledge of the CMMI model, the organization, the business environment, and the specific circumstances involved.

CMMI practices purposely use nonspecific phrases such as "affected stakeholders," "as appropriate," and "as necessary" to meet the needs of different organizations, projects, or points in a single project's development life cycle.

To interpret practices, consider the overall context in which they are used and how well the practice satisfies the goals of a process area within that context. If an activity satisfies process area goals, but differs significantly from CMMI practices, document your rationale for using the alternate practice and make sure that those affected understand this alternative practice. Documented rationales help CMMI assessment teams to understand your choices, to make fair judgments, and to help the others in your organization understand why you are doing things differently.

The CMMI model does not pre-judge which processes are right for you. Instead, it establishes minimal criteria that processes must meet to be considered mature. A mature process is defined, documented, practiced, supported, maintained, controlled, verified, validated, measured, and able to be improved.

To illustrate, a process based on chance (e.g., flipping a coin) could not be improved, so it would not be an acceptable process. Likewise, if a process is based on the expertise of one person on a project, the process cannot be consistent or repeatable without the availability of that person.

The CMMI models are designed to cover the needs of highly structured, large, and complex projects. Keep this in mind when you are interpreting the model for your project. If your organization is small, some of the processes described in the model will not suit the needs of your project without tailoring or interpretation.

Evaluate the effectiveness of processes within the context of the business environment and the specific circumstances of the project and organization. Process capability can be judged using a CMMI model. Process effectiveness is judged using the organization's business objectives.

Understanding Practices

The specific and generic practices in CMMI models are designed to communicate principles that apply to a wide variety of projects and organizations, are valid across a range of products and services, and will remain valid over time. CMMI practices do not require or espouse a particular development or maintenance model, organizational structure, separation of responsibilities, or management and technical approach. Instead, practices provide descriptions of the essential elements of effective processes. Subpractices, notes, and examples sometimes contain implementation methods; however, these are included only to ensure the clarity of the concepts.

Specific terms and examples are consistently used in describing the practices to improve clarity. Refer to the glossary for definitions of these and other CMMI-unique terms.

Organization-Related Terminology

Although CMMI models do not endorse particular organizational structures or roles, terms were chosen to express concepts consistently throughout the model. Understanding our definition of these terms will help you interpret the model for your organization.

CMMI models do endorse one organizational structure to use when impartiality is important: independent groups. Independence of a group empowers its members to be objective, provides protection to its members, and discourages member bias.

The following terms are used throughout the model. Please review them to understand the concepts presented in the model.

A manager provides technical and administrative direction and control to individuals performing tasks or activities within the manager's area of responsibility. The traditional functions of a manager include planning, organizing, directing, and controlling work within an area of responsibility.

A senior manager is a management role at a high enough level in an organization that the primary focus is the long-term vitality of the organization, rather than short-term project and contractual concerns and pressures. The senior manager has authority to direct the allocation or reallocation of resources in support of organizational process improvement effectiveness. A senior manager can be any manager who satisfies this description, including the head of the organization.

A project manager is the person responsible for planning, directing, controlling, structuring, and motivating the project. The project manager is ultimately responsible to the customer. In a matrix organization, only the business staff may report directly to the project manager, whereas the engineering groups would report to the project manager indirectly.

An organizational unit is an administrative structure in which people collectively manage one or more projects as a whole, and whose projects share a top-level manager and operate under the same policies.

A project is a managed set of interrelated resources that delivers products to a customer or end user, has a definite beginning and end, and typically operates according to a plan. The plan specifies the product to be delivered or implemented, the resources and funds to be used, the work to be done, and a schedule for doing the work.

Process-Related Terminology

The following process-related terms are used throughout the model. Please review them to understand the concepts presented in the model.

Process Definition

Process definition is fundamental for achieving higher levels of process capability. The practices in the Organizational Process Definition process area are described using terms that reflect an approach to process definition that supports both stability and flexibility.

A fundamental concept that supports this approach is that processes can be developed and maintained much like other work products. This means that the following can be applied to processes:

- Specify the requirements that define the process.
- Define an architecture and design for the process.
- Implement the process architecture and design.
- Verify and validate the process descriptions.
- Deploy the process into the environment for which it is intended.

Using the analogy of product development, a framework for process development and maintenance has evolved that translates these concepts into ones that are more specific to the process development discipline. The key elements of this framework are called "process assets."

Organizational Process Assets

Organizational process assets are artifacts considered useful for defining and implementing processes in the organization. The organization maintains a collection of process assets for use by projects and other process implementers in developing, tailoring, maintaining, and implementing their processes.

The primary organizational process assets that are described in this CMMI model include the following:

- Organization’s set of standard processes, including the process architectures and process elements
- Descriptions of life cycles approved for use
- Guidelines and criteria for tailoring the organization’s set of standard processes
- Organizational support environment needed to perform the organization’s processes
- Organizational measurement repository process database
- Organizational library of process-related documentation

An organization may bundle these process assets in many ways, depending on its approach to establishing its standard process. For example, the description of the life cycle may be an integral part of the organization's set of standard processes.

Organization's Set of Standard Processes

An organization's set of standard processes contains the definitions of the basic processes that guide all processes in an organization. These process descriptions cover the fundamental process elements (and their relationships to each other) that must be incorporated into the defined processes that are defined and implemented across the organization. A standard process establishes consistent development and maintenance activities across the organization and is essential for long-term stability and improvement.

The organization's set of standard processes form the basis for the defined processes. These standard processes provide continuity in the organization's process activities and are the reference for the measurements and long-term improvement of the defined processes used in the organization.

Process Architectures

A process architecture describes the ordering, interfaces, interdependencies, and other relationships among the process elements in a standard process. A process architecture also describes the interfaces, interdependencies, and other relationships between it and external processes (e.g., contract management).

Process Elements

A process element is an element of a process description. Each process element covers a closely related set of activities (e.g., estimating element, work product inspection element). Process elements can be portrayed using templates to be completed, abstractions to be refined, or descriptions to be modified or used.

Product Life Cycle

A product life cycle is the period of time that begins when a product is conceived and ends when the product is no longer available for use. Since an organization may be producing multiple products for multiple customers, one product life cycle may not be adequate.

Therefore, the organization may define a set of approved product life cycles. These life cycles are typically found in published literature and are likely to be modified to fit the organization. A product life cycle can also be used with the organization's set of standard processes to develop a project's defined processes.

Tailoring Guidelines

The organization's set of standard processes is described at a general level that may not be directly usable to perform a process. Tailoring guidelines are provided to guide the people who establish the defined processes that are implemented in the organization. Tailoring guidelines cover (1) selecting a standard process, (2) selecting an approved product life cycle, and (3) tailoring the selected standard process and life cycle to fit local needs. Tailoring guidelines describe what can and cannot be modified and identify process elements that should be considered for modification.

Organizational Support Environment

The organizational support environment includes the infrastructure (facilities, tools, equipment, and support needed to effectively use them) and tools that people need to perform their jobs effectively. The facilities of the support environment are determined based on the following:

- Organization's set of standard processes
- Needs and objectives of the organization
- Needs associated with developing and maintaining and delivery of the products and services of the organization

Examples of tools and infrastructure components include the following:

- Work space
- Office equipment and supplies
- Computing resources and productivity tools
- Communications systems, tools, and resources
- Testing and simulation facilities
- Prototype-building shops
- Transportation resources
- Raw or stock input materials

An integrated support environment helps people communicate clearly and efficiently about the products, processes, people needs, organization, the business, technical, and political environments, and their interfaces. Integrated communication tool sets reduce wasted time spent converting information from one medium or platform to another

Organizational Measurement Repository

The organizational measurement repository is used to collect and make available measurement data on processes and work products, particularly as they relate to the organization's set of standard processes. This repository contains or references actual measurement data and related information needed to understand and assess the measurement data.

Examples of process and work product data include estimated size of work products, effort estimates, and cost estimates; actual size of work products, actual effort expended, and actual cost amounts; work product inspection efficiency and coverage statistics; and the number and severity of defects.

Organizational Library of Process-Related Documentation

The organizational library of process-related documentation is used to store and make available process documents that are potentially useful to those who are defining, implementing, and managing processes in the organization. This library contains documents, document fragments, process implementation aids, and other artifacts that are useful in defining, implementing, and managing processes that are tailored from the organization's set of standard processes.

Examples of process-related documentation include policies, defined processes, standards, procedures, development plans, measurement plans, and training materials. This library is an important resource that can help reduce the effort required to start a new effort.

Project's Defined Process

The project's defined process is the operational definition of the process used by the project. The project's defined process is described in terms of standards, procedures, tools, and methods. Tailoring the organization's set of standard processes to fit the project develops this process.

The project's defined process provides a base for planning, performing, and improving the project's tasks and activities. A project may have more than one defined process (e.g., one for development of the product and another for testing the product).

Project Development Plan

The project's defined process is usually not specific enough to be performed directly because it doesn't specify who will assume the roles, what work products will be created, or when the tasks will be performed.

The project's development plan, as a single plan or collection of plans, bridges the project's defined process with how the project will be performed. The project's defined process and its development plan together make it possible to perform and manage the process.

Process Management in CMMI Models

Process management covers the practices related to defining, planning, resourcing, deploying, implementing, monitoring, controlling, verifying, and measuring processes. The basic aspects of process management are addressed by both specific and generic practices. In addition, there are process areas that focus on the maturation of process management. Process management process areas address the cross-project responsibilities as the organization matures.

The Scope of Process Management

The Process Management process areas include Organizational Process Focus, Organizational Process Definition, Organizational Training, Organization Process Performance, Organizational Process Technology Innovation, Process Innovation Deployment Integrated Project Management[4], Quantitative Management of Quality and Process, and Causal Analysis and Resolution.

The practices within each process area deal with process management at the local process level (i.e., an individual project, group, organizational function, or standalone process). These practices address the basic things that the people who implement and manage an individual process must do for the process to be effective. There are practices that cover the following aspects of the process:

- Establishing and maintaining written organizational policy
- Establishing and maintaining the requirements, objectives, and plan
- Providing adequate resources
- Assigning responsibility and authority
- Training the people
- Performing the process
- Placing work products under configuration management
- Monitoring and controlling the activities and taking appropriate corrective action
- Objectively verifying adherence and addressing non-compliance

[4] The Integrated Project Management process area belongs both in Process Management and Project Management.

- Reviewing with management and resolving issues

The Evolution of Process Management

Process management practices begin with the above practices and continue to evolve. At first, the focus of process management is on achieving consistency in how processes are defined, implemented, and managed across the organization. The defined processes that are performed at the local level are tailored from the organization's set of standard processes and related organizational process assets to suit the local circumstances in which they will be performed.

The Organizational Process Focus process area contain practices for establishing and maintaining an understanding of the organization's processes and process assets, building an infrastructure to support their use, and planning and coordinating the organization's process improvement activities.

The Organizational Process Definition process area contains practices for establishing and maintaining a usable set of organizational process assets. These process assets include the organization's set of standard processes and supporting assets.

The Organizational Training process area contains practices for developing the skills and knowledge of people so they can perform their roles effectively and efficiently. In particular, this process area deals with providing training to support the organization's strategic needs and cross-project needs. This training is determined, to a large extent, by the organization's set of standard processes.

The Integrated Project Management process area contains practices for managing the project according to an integrated and defined process that is tailored from the organization's set of standard processes. It also deals with using and contributing to the organization's process assets to support consistent process implementation across the organization.

Next, the focus is on achieving statistical predictability for process performance. The performance of the defined process is quantitatively managed using statistical and other quantitative techniques, and product quality, service quality, and process performance are understood in statistical terms.

The organization collects and analyzes the process performance and quality measures from the defined processes to develop a statistical understanding of product quality, service quality, and process performance of the organization's set of standard processes. There are two process areas that describe this process management evolution.

The Quantitative Management of Quality and Process process area contains practices for quantitatively managing the project's defined process to achieve the project's established quality and process performance requirements and objectives.

The Organizational Process Performance process area contains practices for collecting and making available the organizational data, baselines, and models to support quantitatively managing the organization's and project's defined processes. The organization also analyzes these collected measures to assess consistency across the organization, determine best practices, and understand the organization's process performance and quality results.

Finally, the focus is on understanding the common causes of variation inherent in the process and on continually improving process performance through both incremental and innovative technological improvements. Both the defined processes and the organization's set of standard processes are targets of the improvement activities. There are three process areas that describe this process management evolution.

The Causal Analysis and Resolution process area contains practices for improving process performance and quality results by identifying the root causes of defects and other problems, and taking action to prevent them from occurring in the future.

The Organizational Process Technology Innovation process area contains practices for identifying process improvements that would measurably improve the organization's processes and its ability to meet its process related business goals.

The Process Innovation Deployment process area contains practices for continually and measurably improving the organization's processes by systematically transitioning incremental and innovative improvements into use.

Project Management in CMMI Models

Project management covers all activities related to planning, obtaining and assigning resources, and implementing, monitoring, controlling, verifying, and measuring the project's processes. The project management process areas include Project Planning, Project Monitoring and Control, Supplier Agreement Management, Integrated Project Management[5], Risk Management, and Quantitative Management of Quality and Process.

[5] The Integrated Project Management process area belongs both in Process Management and Project Management.

The Scope of Project Management

As defined in the glossary, the term “project” applies to a managed set of interrelated resources, that delivers one or more products or services to a customer or end user, has a definite beginning and end, and typically operates according to a plan. The customer is the individual or organization responsible for accepting the products and authorizing payment to the developing organization. The products may include hardware, software, and other components.

The products and services may be delivered on a single occasion or there may be multiple deliveries. The products and services may be delivered to a single customer or the same product and services may be delivered to many customers (e.g., a commercial off-the-shelf product).

Thus, from a process perspective, a project consists of the processes (and the people and resources performing these processes) that cover the specification, development, maintenance, and delivery of the products and services; the management of the effort; and the support activities such as configuration management and process and product quality assurance.

The Evolution of Project Management

Project management activities evolve as your organization improves its processes. Early on, project management is only as good as the project manager. Later, documented and realistic plans are the basis for managing the project. As processes improve, project management is based on a defined process derived from organizational assets. Even later, quantitative and statistical techniques are used to manage process performance and product quality. Finally, management operates in an environment of continuous improvement.

Project management starts with Project Planning, which lays the groundwork for defining the project by obtaining resources, developing plans, and obtaining commitment from all involved. Once these plans are established and the project gets underway, Project Monitoring and Control is used to ensure the plans are followed, progress is monitored, and action is taken when deviations occur. Supplier Agreement Management is employed in the event the project requires outside products, services, or support.

As project management matures, Integrated Project Management is used to define the project's processes by tailoring the organization's set of standard processes. Integrated Project Management also fosters an integrated management approach in which all commitments are coordinated and managed. Although risk management activities begin with the identification of risks in Project Planning, the Risk Management process area emphasizes the proactive nature of risk management with activities that include risk assessments and risk mitigation planning. Then, statistical process management techniques are used to quantitatively manage the project's defined process to achieve the project's product quality, service quality, and process performance objectives.

Engineering in CMMI Models

The engineering process areas address the activities related to engineering products or services that are shared across engineering disciplines (e.g., systems engineering and software engineering). The engineering process areas include Customer and Product Requirements, Requirements Management, Technical Solution, Product Verification, Validation, and Product Integration.

The Scope of Engineering

The six engineering process areas, depicted in Figure 3 have inherent inter-relationships. These inter-relationships stem from applying a product development process rather than focusing on discipline-specific processes such as software engineering or systems engineering.

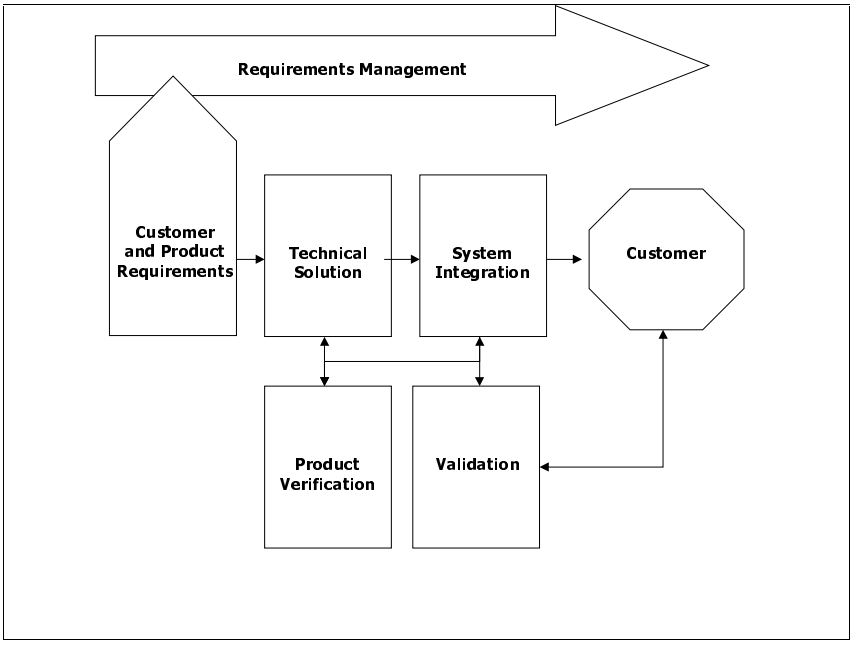

Figure 3: Engineering Process Areas

These engineering process areas integrate software engineering and systems engineering processes into a product-oriented process improvement scenario. Improving product development processes targets essential business goals, rather than specific disciplines. This approach effectively avoids the tendency toward an organizational "stove-pipe" mentality.

These engineering process areas apply to the development of any product or service in the engineering development domain (e.g., software products, hardware products, or service processes).

The development of a product or service starts with the needs, expectations and constraints of a customer. The Customer and Product Requirements process area identifies customer needs and translates these needs into customer and product requirements and develops a preliminary functional architecture. The customer may be an external customer who provides a set of requirements, or an internal customer typically, marketing, or systems engineering. Customer requirements are written in the customer's language, sometimes very general, sometimes performance specific, and in general written to meet the mission or usability needs.

This set of requirements is then translated into a set of product requirements that implement the customer's requirements and, in addition, may impose other requirements to help define the product, that the developer deems necessary. This set of product requirements clearly describes what the product's performance, design features, verification requirements, etc. are in terms the developer uses and understands.

The translation of customer requirements into product requirements involves the simultaneous evolution of a preliminary functional architecture. This preliminary functional architecture assigns customer requirements to functional entities; thus starting the functional decomposition necessary to eventually describe the product to be developed. The preliminary functional architecture will be further decomposed in the Technical Solution process area.

The Requirements Management process area maintains the requirements. It describes practices for obtaining and controlling requirement changes, and ensuring other relevant plans and data are kept current.

Requirements Management ensures that changes to requirements are reflected in project plans, activities, and work products. This cycle of changes may impact all the other engineering process areas, thus requirements management is a dynamic and often recursive sequence of events. Establishment and maintenance of the Requirements Management process area is fundamental to a controlled and disciplined engineering design process.

Traceability of requirements from customer, to product, to component requirements is addressed by this process area.

The Technical Solution process area designs and builds product components that will be used by the Product Integration process area. The examination of alternative design solutions; with the intent of selecting the optimum design based upon established criteria is expected. These criteria may be significantly different across products, depending on product type, operational environment, performance requirements, support requirements, and cost or delivery schedule. The task of selecting the final design makes use of the practices in the Decision Analysis and Resolution process area.

The Technical Solution process area relies on the practices in the Product Verification process area to perform design verification testing and work product inspections during design and prior to final build. In addition, the Technical Solution process area makes use of the Validation process area to ensure that the design of the product meets the customer needs.

The Product Verification process area ensures the product meets the specified product requirements. Product Verification process area expects a verification strategy and plan are developed to ensure adequate design and product verification. This verification strategy and plan is highly integrated with the Technical Solution process area and the Product Integration process area. It is generally an incremental process starting with component verification and usually concludes with verification of fully assembled products.

Product verification also addresses work product inspections. These work product inspections or peer reviews are a proven method of defect reduction in product development and maintenance.

The Validation process area validates products against the customers needs and requirements. Validation is usually performed in the operational environment or a simulated operational environment. Coordination with the customer on the validation requirements and the validation plan is one of the most essential elements of this process area.

The scope of the Validation process area includes validation of requirements as well as validation of products and processes. Validation may often require re-verification and re-validation of work products and is therefor tightly coupled to the other engineering process areas.

The Product Integration process area establishes the expected practices associated with integrating product components, performing an acceptance procedure, and delivering the product to the customer.

Product Integration uses the practices of both Product Verification and Validation in implementing the product integration process. Product Verification verifies the interfaces and interface requirements between product components prior to product integration; this is a key event in the integration process. During product integration in the operational environment, the practices of the Validation process area are used.

Product Integration addresses acceptance testing to ensure proper product functional performance and acceptable physical attributes. Subsequent to acceptance testing the product is properly packaged and shipped.

The Evolution of Engineering

Engineering activities such as requirements analysis, design, and test are commonly performed by organizations just beginning process improvement efforts. However, there are other engineering activities that evolve as your organization's processes improve. Initially, the focus is on project management and therefore managing requirements is emphasized. Once an organization is proficient in project management, the focus can shift to the engineering processes. Later, the focus is on engineering discipline. As processes improve, the focus is on quantitative product control. Finally, the focus is on continuous measured improvement.

Measurement in CMMI Models

The Need for a Measurement and Analysis Process Area

As software engineering and systems engineering become more integrated, the proper implementation and institutionalization of measurement and analysis practices becomes more important. Measurement practices are integral to basic management activities such as project planning, monitoring, and control.

Likewise, as organizations mature, management that is objective and performance based relies on measurement practices. Basic project-management measures such as cost, milestone completion, and defects are augmented by measures of process performance, and process and change management. Measurement becomes integrated into life-cycle processes to support decision making, and to help guide product and process improvement.

However, this transition toward more measurement practices can be difficult, especially for those not familiar with good measurement practice. How to effectively use measurement to support decision making is a common difficulty in many organizations.

Applying measurement successfully requires collaboration and coordination across organizational roles and perspectives. It requires not only measurement expertise, but also business and engineering perspectives.

It was sometimes difficult to follow the implicit threads of measurement concepts in previous process improvement models. Organizations that have succeeded in establishing successful measurement programs often comment that they could have saved time and avoided problems had they had more guidance on how to implement measurement practices. In fact, as part of tailoring previous models, some organizations have created measurement process areas.

How measurement is represented in a model affects how it is perceived and used. Historically, most models did not include a measurement process area even though model users wanted more measurement-specific information. After all, like other support functions, the correct use of measurement follows a process that can be described.

Recent models and emerging ISO standards have included a measurement process area with complete and detailed guidance. [6] The incorporation of the Measurement and Analysis process area in the CMMI Product Suite provides the visibility and focus needed to guide the use of measurement in process improvement efforts.

How Measurement Fits in the Model

The practice of measurement and analysis is always done in the context of performing other processes. In CMMI models, there are two sources of measurement guidance: the Measurement and Analysis process area and the practices that fall under the institutionalization common features. The process area provides a central focus for good measurement practice and the measurement-related generic practices show how measurement fits into CMMI models.

The purpose of the Measurement and Analysis process area is to develop and sustain a measurement capability in support of management information needs. Its practices are organized under two goals: (1) alignment of measurement activities with established information needs and objectives, and (2) providing data analyses and results that address those needs and objectives.

Every process area is dependent to some extent on the proper use of measurement. As illustrated in Figure 4, some process areas are sources of contractual requirements, business objectives, and other information needs. [7] In turn, the results of measurement activities are provided for those same process areas.

[6] In combination with the model's generic practices, the Measurement and Analysis process area is fully compliant with the ISO/IEC 15504 and ISO/IEC 15939 emerging standards.

[7] The figure is adapted from the Scope of Standard diagram that appears in ISO/IEC CD 15939.

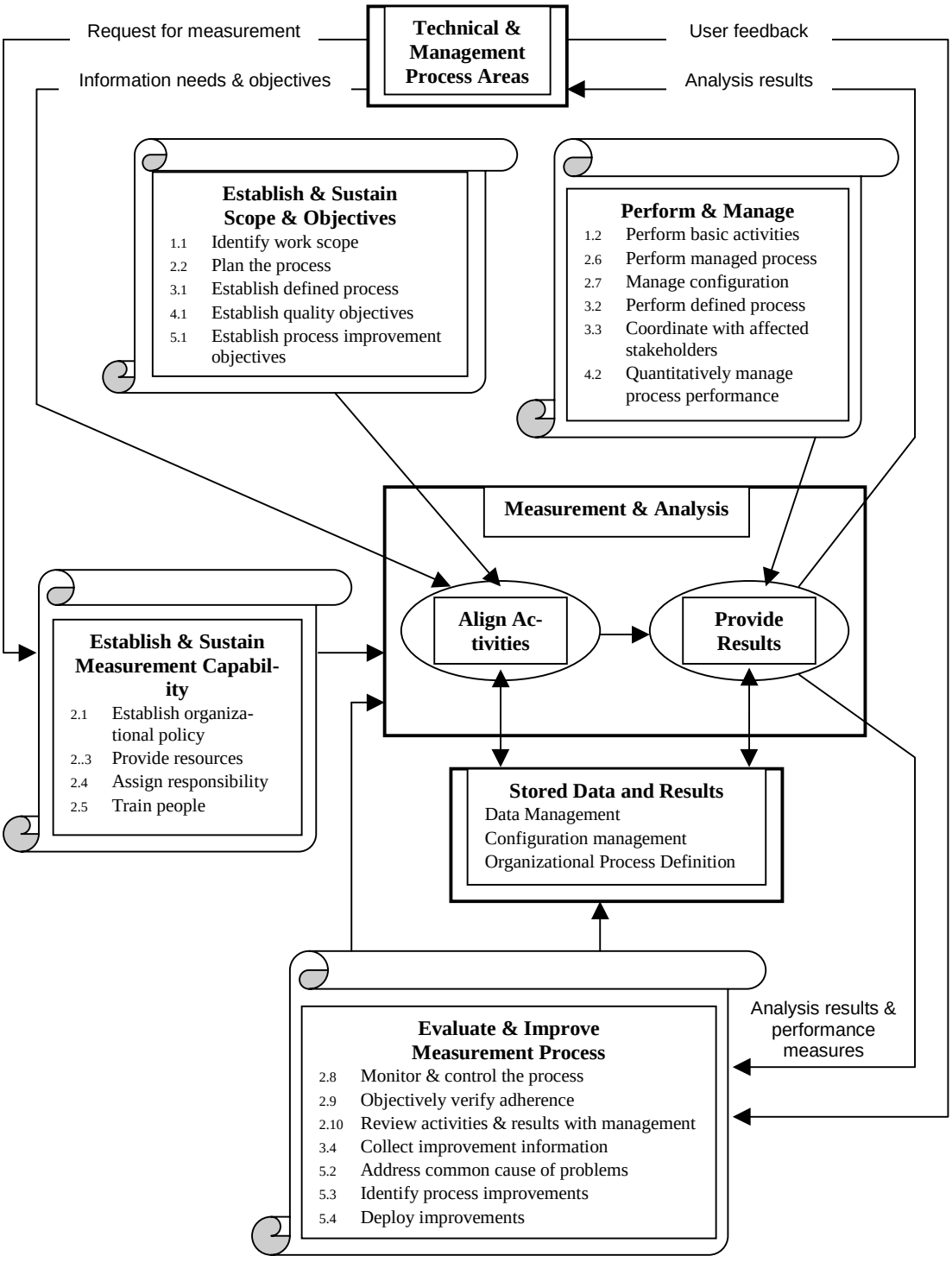

Figure 4: The Use of Measurement in CMMI Models

However, the Measurement and Analysis process area does not stand alone. It is used in concert with the measurement-related generic practices. These generic practices serve to help institutionalize measurement and analysis.

These practices provide guidance for planning and related activities; performing the measurement and analysis and reporting results; providing the organizational infrastructure necessary to implement any process; and providing a basis for improving the manner in which future measurement and analysis is done.

All requests for measurement are channeled through the "Establish & Sustain Measurement Capability" practices. Similarly, user feedback is channeled through these practices.

The model makes no assumptions about how measurement and analysis is implemented in the organization's structure. It may be a function of an engineering process group, a separate measurement unit, or be fully integrated into development projects.

Finally, the Measurement and Analysis process area relies on other process areas that focus heavily on storing measurement data and analysis results. Collectively, these process areas provide the experience on which measurement and analysis relies.

The Evolution of Measurement Capability

Measurement is ever present throughout systems engineering and software engineering practices.[8] In fact, measurement applies in some way to every process area in the model.

Measurement is commonly used for basic project planning and tracking. Eventually measurement becomes a part of doing business. Early on, measurement is indispensable for the proper implementation of the Project Planning and Project Monitoring and Control process areas. Examples include measuring and analyzing requirements volatility, quality assurance information on process compliance, or progress of work units under configuration management.

Establishing performance baselines provides a basis for subsequent analyses of process improvements, their costs and benefits. Measures introduced early can be expanded to include product quality, resource, size, and stability measures. Finally, the preparation begun early with Measurement and Analysis is essential to preparing for all of the later work, as process improvement efforts proceed.

[8] The pervasive need for measurement is evident in the Defense Acquisition Deskbook (DAD, http://www.deskbook.osd.mil) which has 1069 uses of "measurement" in mandatory documents and 2738 uses of "measurement" in discretionary documents.

Measurement can support the implementation of any of the management or engineering process areas in which measurement expertise is more widely focused throughout the organization. Measurement data is stored in repositories that are available for use throughout the organization. Analyses begin to focus on explicit comparisons among projects and roll ups across the organization.

The project-oriented management begun earlier with Project Planning and Project Monitor and Control matures into the Quantitative Management of Quality and Process process area. Better quantitative management using Organizational Process Performance is enhanced by comparisons made among projects and across the organization.

Finally, the proper use of measurement becomes necessary for the Causal Analysis and Resolution process area. Measurement is also crucial for the quantitative management of process improvement as described in the Organizational Process Technology Innovation and Process Innovation Deployment process areas.

Measurement is applied differently as the organization successfully satisfies the goals of more CMMI process areas. Measurement's role typically begins by clarifying business objectives and satisfying needs for information and translating them into measurable objectives.

At first, the results of measurement often use simple charts and graphs. As the organization matures, more sophisticated quantitative analyses are used, such as statistical process control, structural modeling, or other multivariate statistical methods.

The measurement elements in a CMMI model provide an evolutionary means of increasing the capability with which the organization can develop a quantitative understanding of process performance and product quality. These measurement elements support the establishment and achievement of specific product improvement objectives, control process performance using quantitative information, and ensure the feasibility of plans and the adherence of activities to those plans.

Advanced Practices

Advanced practices are specific practices that are not essential to the basic implementation of the process area. Advanced practices describe a more advanced implementation of the process area.

4 Using The Model

The CMMI models provide a set of publicly available criteria describing the characteristics of organizations that have successfully implemented process improvement. These criteria can be used by organizations to improve their processes for developing and maintaining products and services.

The CMMI project has worked to preserve the government and industry investments in process improvement and to enhance the use of multiple models. In addition to improving the usability of CMM technology in a wider set of disciplines, the CMMI concept calls for use of common terminology, common components, common assessment methods, and common training materials. The goal is to reduce the cost of training and other process improvement efforts needed by users of multiple disciplines.

Assessment

Process assessments focus on identifying improvement priorities within an organization's own process. Assessment teams use the CMMI models to guide them in identifying and prioritizing findings. These findings, along with guidance provided by the key practices in the CMMI models, are used (by an engineering process group, for example) to plan an improvement strategy for the organization.

For organizations that wish to assess against multiple disciplines (e.g., software engineering and system engineering), the unified CMMI approach permits some economy of scale in model training and assessment training. One assessment method can provide separate or combined results for multiple disciplines. The assessment products will also allow the assessment of a single discipline, as in the past. The CMMI assessment products will provide consistent findings for staged and continuous representations with equivalent staging.

The assessment principles for the CMMI Product Suite remain the same as those used in past assessments using the SW-CMM and SECM models: senior management sponsorship, a focus on the organization's business goals, confidentiality for interviewees, use of a documented assessment method, use of a process reference model (e.g., a CMMI model) as a base, a collaborative team approach, and a focus on actions for process improvement.

Assessment Requirements for CMMI (ARC)

The Assessment Requirements for CMMI (ARC) is a set of guidelines for developing, defining, and using assessment methods based on CMMI products. The ARC provides requirements for multiple types of assessment methods with guidelines for determining the suitability of a particular assessment method. Suitability addresses the accuracy and repeatability of assessment results.

The ARC uses the CMMI models as its associated reference models. The CMM Appraisal Framework (CAF) v1.0 was originally produced to address assessment methods associated with the CMM for Software only. With the incorporation of CMMs into the CMMI architecture, the ARC has been created to address these new models and the resulting impacts of the staged and continuous representations of each model.

The ARC was designed to help improve consistency across multiple disciplines and assessment methods, and to help assessment method developers, sponsors, and users understand the trade-offs associated with various methods. Not all assessment methods are expected to be fully ARC compliant.

Other CMMI-based assessment methods may be appropriate for a given set of sponsor needs, including self-assessments, initial assessments, quick-look or mini-assessments, incremental assessments, and external audit evaluations. Method developers are expected to develop a variety of assessment methods to meet these needs.

Whether a method developer complies with the ARC, and how it implements ARC requirements is a method-specific choice. It is up to users of assessment method outcomes to translate the results of ARC assessments into meaningful information that meets the sponsor's business needs. When an assessment method meets all of the ARC requirements, it is said to be fully ARC-compliant.

Standard CMMI Assessment Method for Process Improvement (SCAMPI)

As part of the CMMI Product Suite, a comprehensive assessment method called the Standard CMMI Assessment Method for Process Improvement (SCAMPI) is being developed by the CMMI product team. The team is using the CMM-Based Appraisal for Internal Process Improvement (CBA IPI) v1.1 and the Systems Engineering Capability Model (SECM) assessment method (EIA/IS 731, Part 2) as sources for this new method.

The CBA IPI method was developed and introduced by the Software Engineering Institute in prototype form and field tested in 1994; version 1.0 was released in May 1995, and the current version 1.1 was released in March 1996. Results from the use of the CBA-IPI method, using CMM for Software v1.1 as a reference model, have been returned to the SEI for approximately 650 assessments as of November 1998. Results of these assessments reside in the SEI's Process Appraisal Information System (PAIS).

The SECM assessment method is a merger of assessment methods and is used with the System Engineering Capability Model (SECM) and the System Engineering Capability Assessment Method (SECAM). This assessment method, as well as the two predecessor methods, has been used by many organizations.

SCAMPI is being proposed for use with all of the CMMI models, both staged and continuous representations. Training in the use of the assessment method will be essentially the same for each model, with adaptations of exercises and work aids to the particular representation being used.

Details of the SCAMPI method are still in development, but the method will consist of three main phases: planning, conducting, and reporting results. Planning is done over a 2-3 month period of time, which includes training the assessment team members in the reference model and in performing the assessment process.

Conducting the assessment consists of an on-site period of 5-10 days and includes data collection through the use of questionnaires and interviews with appropriate organizational staff. Results are reported in the form of strengths and weaknesses relative to the process areas of the CMMI model in a briefing to the assessment sponsor and the assessed organization. Capability level ratings of the process areas (for the continuous representation) and maturity level ratings (for the staged representation) may also be reported.

SCAMPI is being written to permit conformance with the emerging ISO/IEC TR 15504 standard. ISO/IEC TR 15504 is an international collaboration to develop a standard set of technical reports on software process assessment that has been underway since June 1993 under the auspices of the International Organization for Standardization and the International Electrotechnical Commission (ISO/IEC). For those sponsors interested in performing a 15504-conformant assessment, SCAMPI will support these needs.

For benchmarking against other organizations, assessments must ensure consistent ratings. The achievement of a specific maturity level or the satisfaction of a specific process area must mean the same thing for different assessed organizations. Rules for ensuring this consistency will be provided in the SCAMPI method description.

Training

Training is a key part of the technology adoption process. To make the training effective, it must be focused on audience needs. For CMMI training, audience needs fall into the following broad categories:

- Model oriented training
- Assessment oriented training

Both categories of training have proven to be critical to rapid and successful adoption of a new process improvement model. Other groups of training are also evolving in importance for CMMI product adoption, such as train-the-trainer programs, process improvement training, and training in support concepts like measurement, to name a few.

The early CMMI training materials will rely heavily on existing CMM-based training course designs. The commonality is being reviewed and restructured for consistency. The initial set of CMMI courses will be at the introductory level and address each model and each representation - staged and continuous. Team training for assessments is also planned for inclusion in the initial training material. Lead assessor training is planned for future training materials.

5 Capability Levels

Capability Level 0: Incomplete

An incomplete process is a process that is not performed or only performed partially. One or more of the specific goals of the process area are not satisfied.

Capability Level 1: Performed

A performed process is a process that accomplishes the needed work to produce identified output work products using identified input work products. The specific goals of the process area are satisfied.

Those responsible for performing the process may also establish other objectives, such as quality, cost, and schedule objectives for their specific situation. For example, an objective might be to reduce the cost of performing a process for this implementation over the previous implementation. The achievement of these specific objectives may not be managed effectively and the achievement of these objectives is often unpredictable.

A critical distinction between an incomplete process and a performed process is the completeness of the process. An incomplete process is missing some of the basic activities. It fails to satisfy the specific goals of the process area. It fails to accomplish the needed work or fails to transform the identified input work products to produce identified output work products. A performed process satisfies the specific goals of the process area. It includes the essential activities, accomplishes the work, and produces the identified output work products. However, the definition, planning, monitoring, and controlling of the process may be incomplete, thereby resulting in an unstable and inconsistently implemented process.

Level 1 Generic Goals

Achieve Specific Goals The implemented process achieves the specific goals of the process area.

Level 1 Generic Practices

Identify Work Scope

Identify the scope of the work to be performed and work products to be produced, and communicate this information to those performing the work.

The purpose of this practice is to ensure that the people doing the work have a common understanding of the work to be performed and work products to be produced.

The scope of the work to be performed and the input and output work products are determined based on an understanding of the stakeholders' requirements.

Perform Basic Activities

Perform the basic activities of the process to develop work products and provide services to achieve the specific goals of the process area.

The purpose of this practice is to produce the work products and deliver the services that are expected from performing the process. These activities may be done informally, not following a documented process description or plan. The rigor with which the activities are performed depends on the individuals managing and performing the work and may vary considerably.

The "basic activities" are the activities needed to address the capability level 1 specific practices of the process area.

Capability Level 2: Managed

A managed process is a performed process that is planned, documented, performed, monitored, and controlled at the local level. Management of the process is concerned with the achievement of the specific goals of the process area; the adherence of the process and their work products to the applicable requirements, policies, and standards; and the achievement of other specific objectives for the process, such as cost, schedule, and quality objectives.

A critical distinction between a performed process and a managed process is the consistency of implementation of the process. A performed process achieves the specific goals of the process area, but the process is likely to be unstable and inconsistently implemented. A managed process also achieves the specific goals of the process area, but is planned, documented, monitored, and controlled. Another critical distinction is that a managed process achieves the other objectives that are established for the process, such as cost, schedule, and quality objectives. A performed process may not achieve all these objectives.

The term "local" refers to the level in an organization where the process is actually performed. That level may be an individual project, group, organizational function, or standalone process.

Those responsible for performing the process establish these objectives for their situation, and revise them as appropriate. These objectives are determined based on an understanding of what will satisfy the stakeholders. Objectives may be quantitative or qualitative. (e.g., An objective might be to reduce the cost of performing a process for this implementation over the previous implementation.)

The objectives for the process may be specific objectives for the individual process or they may be defined at a higher level (i.e., for a set of processes), with the individual processes contributing to achieving these objectives. These objectives may be revised as part of the corrective actions taken for the process.

The process discipline of a managed process helps ensure that existing practices are retained during times of stress. When these practices are used on efforts similar to the current effort, similar results can be expected.

The requirements, standards, and objectives for the process, its work products, and its services are defined and documented. The status of the work products and delivery of the services are visible to management at defined points (e.g., at major milestones and completion of major tasks). Commitments are established among those involved in performing the work and affected stakeholders. Commitments are revised as needed and satisfied. Work products are reviewed with affected stakeholders and are controlled. The work products and services satisfy their specified requirements, standards, and objectives.

A managed process is institutionalized by doing the following:

- Adhering to organizational policies
- Following a documented plan and process description
- Applying adequate and appropriate resources (including funding, people, and tools)

- Maintaining appropriate assignment of responsibility and authority
- Training the people performing and supporting the process
- Placing work products under appropriate levels of configuration management
- Measuring the process, its work products, and its services
- Monitoring and controlling the performance of the process, and taking corrective actions
- Objectively reviewing the process, its work products, and its services, and addressing non-compliance
- Reviewing the activities, status, and results of the process with appropriate levels of management, and taking corrective actions

Institutionalization also implies that the breadth and depth of the implementation of the process and the length of time the process has been in place is appropriate to ensure that the process is an ingrained part of the way the work is performed.

Level 2 Generic Goals

Institutionalize a Managed Process The process is institutionalized as a managed process.

Level 2 Generic Practices

Establish an Organizational Policy

Establish and maintain a written organizational policy for planning and performing the process.

The purpose of this practice is to define the organizational expectations for the process and make these expectations visible to those in the organization who are affected.

Organizational policies are typically established by the organization's senior management. Senior management serves in a management role at a high enough level in an organization that their primary focus is the long-term vitality of the organization, rather than short-term work concerns and pressures. Organizational policies may be established by senior managers who either manage the entire organization or manage at lower levels in the organization (e.g., a business area or a product line).

Plan the Process

Establish and maintain the requirements, objectives, and plan for performing the process.

The purpose of this practice is to determine what is needed to perform the process and achieve the established objectives, prepare a plan for performing the process, and get agreement on the plan from affected stakeholders.

The requirements for the process include requirements for the delivered products and services, as well as requirements for performing the work (e.g., requirements for controlling and delivering products and services).

The objectives for the process are established by those responsible for performing the process. Included are objectives for their specific situation, including quality, cost, and schedule objectives. For example, an objective might be to reduce the cost of performing a process for this implementation over the previous implementation.

Establishing a plan includes documenting it. Maintaining the plan includes changing it, as necessary, as a result of corrective actions, changes to the process, and changes to the requirements and objectives for the process.

Subpractices

1. Obtain management sponsorship for performing the process.

2. Define and document the process description.

   The process description, which includes relevant standards and procedures, may be included as part of the plan for the process or may be included in the plan by reference.

3. Define and document the plan for performing the process.

   This plan may be a stand-alone document, embedded in a more comprehensive document, or distributed across multiple documents. Documents may be hardcopy or softcopy.

   The plan for performing the process typically covers the following:

   - Standards for the work products and services of the process
   - Life cycle model for the process
   - Requirements for the work products and services of the process
   - Specific objectives for the performance of the process (e.g., quality, time-scale, cycle time, and resource usage)
   - Schedule for performing the process
   - Dependencies among the activities, work products, and services of the process
   - Resources (including funding, people, and tools) needed to perform the process
   - Assignment of responsibility and authority

- Training needed for performing and supporting the process
- Items to be placed under configuration management and the level of configuration management for each item
- Measurement requirements to provide insight into the performance of the process, its work products, and its services
- Activities for monitoring and controlling the process
- Objective verification activities for the process and the work products
- Management review activities for the process and the work products

4. Review the plan with affected stakeholders and get their agreement.
5. Revise the plan as necessary.

Provide Resources

Provide adequate resources for performing the planned process, developing the work products and providing the services of the process.

The purpose of this practice is to ensure that the resources needed to perform the process as defined by the plan are available when they are needed. Resources include adequate funding, appropriate physical facilities, skilled people, and appropriate tools.

The interpretation of the term "adequate" depends on many factors and may change over time. Inadequate resources may be addressed by increasing resources or by removing requirements, constraints, and commitments.

Subpractices

1. Provide funding that covers all aspects of performing the process.
2. Provide appropriate physical facilities.
3. Provide appropriate tools, as needed, to support performing the process.
4. Provide skilled people.

   The people provided should have the general skills needed to perform the type of work needed to perform the process. Training is provided to address the skills needed for the specific implementation of the process and to bridge skill gaps.

Assign Responsibility

Assign responsibility and authority for performing the planned process, developing the work products, and providing the services of the process.

The purpose of this practice is to ensure that there is accountability, over the life of the process, for performing the planned process and achieving the specified results. The people assigned must have the appropriate authority to perform the assigned responsibilities.

Responsibility can be assigned using detailed job descriptions or by living documents, such as a plan for the process. Dynamic assignment of responsibility is another legitimate way to perform this practice, so long as the assignment and acceptance of responsibility is assured over the life of the process.

Subpractices

1. Assign overall responsibility and authority for performing the process.
2. Assign responsibility for performing the specific tasks of the process.
3. Confirm that the people assigned the responsibilities and authorities understand and accept them.

Train people

Train the people performing or supporting the planned process as needed.

The purpose of this practice is to ensure that the people have the necessary skills and expertise to perform or support the performing of the planned process.

Appropriate training is provided to the people who will be performing the work and who lack the necessary skills and expertise. Overview training is provided to orient people who interact with those performing the work.

Training supports the successful performing of the process by establishing a common understanding of the process and by imparting the skills and knowledge needed to perform the process.

Perform Managed Process

Perform the process as a managed process.

The purpose of this practice is to include the capability level 2 generic practices with the specific practices of the process area and perform the planned process utilizing the additional capabilities that a managed process provides over a performed process.

Manage Configurations

Place designated work products of the implemented process under appropriate levels of configuration management.

The purpose of this practice is to establish and maintain the integrity of the work products of the process throughout the life cycle of the process.

The term "designated" work products implies that the work products that are to be controlled are identified (i.e. designated). As part of this identification, the level of configuration management and the points in the life cycle that each will be placed under configuration management are also defined.

Different levels of configuration management are appropriate for different work products and for different phases of the life cycle. For some work products, it may be sufficient to maintain version control (i.e., the version of the work product in use at a given time, past or present, is known and changes are incorporated in a controlled manner). Version control is usually under the sole control of the work product owner.

For other work products, it may be critical that they be placed under formal or "baseline" configuration management. This type of configuration management includes defining and establishing baselines at predetermined points. These baselines are formally reviewed and agreed on and serve as the basis for further development. A rigorous change control process is applied the baselines.

Additional levels of configuration management between version control and formal configuration management are possible. An identified work product may be under various levels of configuration management at different phases of the life cycle.

Monitor and Control the Process

Monitor and control the performing of the implemented process, developing of the work products, and providing of the services against the plan for the process, and take appropriate corrective action.

The purpose of this practice is to perform the direct day-to-day monitoring and controlling of the process implementation. Appropriate visibility into the performing of the process is maintained so that appropriate corrective actions can be taken when necessary.

Subpractices

1. Collect and analyze measures of actual performance against the plan.

The measures are of the process, its work products, and its services.

2. Review accomplishments and results of the implemented process against the planned process.

3. Verify that the work products and services satisfy their requirements and objectives.

4. Identify and evaluate the effects of significant deviations from the planned process.

5. Identify problems in the planned and implemented process.

6. Take corrective action when requirements and objectives are not being satisfied, when issues are identified, or when progress differs significantly from the planned process.

   Corrective action may include the following:

   - Taking remedial action to repair defective work products or services
   - Changing the planned process
   - Adjusting resources, including people, tools, and other resources
   - Negotiating changes to the established commitments
   - Securing change to the requirements and standards that have to be satisfied
   - Terminating the effort

   There are inherent risks that need to be considered before any of the corrective actions are taken.

7. Track corrective action to closure.

Objectively Verify Adherence

Objectively verify adherence of the planned process, implemented process, and the work products of these processes to the applicable requirements and standards, and address non-compliance.

The purpose of this practice is to provide credible assurance to the process managers, implementers, and senior managers that the planned process satisfies the applicable policies, plans, requirements, and standards, the implemented process satisfies the planned process, and the results of the process satisfy their requirements and standards.

Verification of adherence is typically done by people who are not directly responsible for managing or performing the activities of the process. As a result, credible assurance of adherence can be provided even during times when the process is under stress (e.g., when the effort is behind schedule or over budget).

Subpractices

1. Objectively verify adherence of the implemented process to the applicable requirements, plans, processes, standards, and procedures, and address non-compliance.

2. Objectively verify adherence of work products to the applicable requirements and standards, and address non-compliance.

   Verifying adherence of work products, in this context, includes determining whether the work product adheres to the applicable standards and whether the content of the work product addresses the requirements allocated to it. It does not include the detailed verification that ensures the work product completely and correctly satisfied each requirement allocated to it.

Review Activities and Results with Management

Review the activities, status, and results of the implemented process with management and resolve issues.

The purpose of this practice is to provide the various levels of management in the organization, above the immediate level of management responsible for the process (e.g., senior management), appropriate visibility into the process. These reviews are for managers who provide sponsorship and overall guidance for the process, not for those who perform the direct day-to-day monitoring and controlling of the process.

Different managers have different needs for information on the process. These reviews help ensure an environment in which decisions on the planning and performing of the process can be made appropriately. Therefore, these reviews are expected to be both periodic and event-driven.

Senior management serves a management role at a high enough level in an organization that their primary focus is the long-term vitality of the organization, rather than short-term work concerns and pressures.

Capability Level 3: Defined

A defined process is a managed process that is tailored from the organization's set of standard processes and related organizational process assets to suit the local circumstances in which it will be performed. The define process is well characterized and understood and is described in terms of standards, procedures, tools, and methods.

The organization's set of standard processes, which are the basis of the defined process, are established and improved over time. These standard processes contain the definitions of the basic processes that are used for establishing common processes across the organization. Basic processes describe the fundamental process elements that are expected in the defined processes. Basic processes also describe the relationships (e.g., the ordering and interfaces) between these process elements. The organization-level infrastructure to support current and future use of the organization's set of standard processes is established and improved over time.

The organization's management establishes process objectives based on the organization's set of standard processes. These process objectives are appropriately addressed in the defined processes.

A defined process clearly states the following:

- Purpose
- Inputs
- Entry criteria
- Activities
- Roles
- Measures
- Verification steps
- Outputs
- Exit criteria

A defined process is institutionalized by doing the following:

- Satisfying the items that institutionalize a managed process
- Establishing the description of the defined process
- Establishing a plan based on the description of the defined process
- Performing the process according to the planned defined process
- Communicating, coordinating, and collaborating with affected stakeholders by the process, its work products, and its services Collecting work products, measures, and improvement information derived from planning
- and performing the process to support the future use and improvement of the organization's process assets

Institutionalization also implies that the breath and depth of implementation of the process and the length of time the process has been in place is appropriate to ensure that it is ingrained as part of the way the work is performed.

A critical distinction between a managed process and a defined process is the scope of application of the standards, process descriptions, and procedures. For a managed process, the standards, process descriptions, and procedures may be in use in only a specific instance of the process (e.g., on a particular project). For a defined process, the standards, process descriptions, and procedures are tailored from organizational process assets. As a result, the defined processes that are performed across the organization are appropriately consistent. Another critical distinction is that a defined process is described in more detail and more rigorously than a managed process. Management of the defined process is based on the additional insight provided. The process is managed more proactively using an understanding of the interrelationships of the process activities and detailed measures of the process, its work products, and its services.

Level 3 Generic Goals

Institutionalize a Defined Process The process is institutionalized as a defined process.

Level 3 Generic Practices

Establish Defined Process

Establish and maintain the description of the defined process to meet specific local and organizational needs.

The purpose of this practice is to establish a description of the planned defined process that is tailored from the organization's set of standard processes to address local needs. With a defined process, variability in how the processes are performed across the organization is reduced and process assets, data, and learning can be effectively shared.

The term "local" refers to the level in an organization where the process is actually performed. That level may be an individual project, group, organizational function, or standalone process.

The descriptions of the defined processes provide the basis for planning, performing, and managing the activities, work products, and services associated with the process.

For some processes (particularly organizational processes), the organization's set of standard processes may contain the appropriate detail and specificity needed to perform the process. In these cases no tailoring is performed and the defined process is the same as the standard process.

Subpractices

1. Select a life-cycle model for the process from those approved for use in the organization.
2. Select the standard process from the organization's set of standard processes that best fit the specific local needs.
3. Establish the defined process by tailoring the selected standard processes, life cycle model, and other process assets according to the organization's tailoring guidelines.
4. Ensure that the organization's process objectives are appropriately addressed in the defined process.
5. Document the defined process and the records of the tailoring.
6. Revise the description of the defined process as necessary.

Perform Defined Process

Perform the process as a defined process.

The purpose of this practice is to include the capability level 2 and 3 generic practices with the specific practices of the process area and perform the process utilizing the additional capabilities that a defined process provides over a managed process.

Coordinate with Affected Stakeholders

Communicate, coordinate, and collaborate with the stakeholders affected by the process, its work products, and its services.

The purpose of this practice is to establish and maintain a mutual understanding of the process requirements, commitments, activities, and results; make decisions collaboratively; and identify, track, and resolve coordination issues.

Subpractices

1. Establish and maintain an understanding with affected stakeholders on the requirements for the process.
2. Participate with affected stakeholders to coordinate the activities of the process.
3. Participate with affected stakeholders to identify, negotiate, and track critical coordination commitments, dependencies, and issues.

Collect Improvement Information

Collect work products, measures, and improvement information derived from planning and performing the process to support the future use and improvement of the organization's processes and process assets.

The purpose of this practice is to collect information and artifacts derived from planning and performing the process so that the information and artifacts can be included in the organization's process assets and made available to those who are or will in the future planning and performing the same or similar processes. The information and artifacts are stored in the organizational measurement repository and the organizational library of process-related documentation.

Subpractices

1. Propose improvements to the organization's process assets.
2. Store process and product measures in the organizational measurement repository.

   The process and product measures are primarily those that are defined in the organization's common set of measures for the set of standard processes.
3. Submit documentation for inclusion in the organizational library of process-related documentation.
4. Document lessons learned from the process for inclusion in the organizational library of process-related documentation.

Capability Level 4: Quantitatively Managed

A quantitatively managed process is a defined process that is controlled using statistical and other quantitative techniques. Quantitative objectives for product quality, service quality, and process performance are established and used as criteria in managing the process. The product quality, service quality, and process performance are understood in statistical terms and are managed throughout the life of the process.

The quantitative objectives are based on the needs of the customer, end-users, organization, and process implementers.

The people performing the process are directly involved in quantitatively managing the process.

Quantitative management is performed on the overall set of processes that produces a product or provides a service. The processes that are significant contributors to the overall process performance are quantitatively managed. For these selected processes, detailed measures of the process performance are collected and statistically analyzed. Special causes of process variation are identified and, where appropriate, the source of the special cause is addressed to prevent future occurrences.

The product quality, service quality, and process performance measures are incorporated into the organizational measurement repository to support future fact-based decision-making.

A quantitatively managed process is institutionalized by doing the following:

- Satisfying the items that institutionalize a defined process
- Establishing and maintaining quantitative objectives for product quality, service quality, and process performance
- Establishing and maintaining a statistically stable and predictable process performance
- Establishing and maintaining a statistical understanding of the capability of the process to achieve the quantitative objectives for product quality, service quality, and process performance

Institutionalization also implies that the breadth and depth of implementation of the process and the length of time the process has been in place is appropriate to ensure that it is ingrained as part of the way the work is performed.

A critical distinction between a defined process and a quantitatively managed process is the predictability of the process performance. The performance of a quantitatively managed process is controlled using statistical and other quantitative techniques, and statistical predictability for the results is achieved. A defined process only provides qualitative predictability.

The term "quantitatively managed" implies using appropriate statistical and other quantitative techniques to manage the performance of a process so that it is quantitatively stable and its capability to achieve established quantitative objectives is known. Activities for managing the performance of a process includes the following:

- Identifying and measuring product and process attributes that are important contributors to product quality, service quality, and process performance
- Identifying and addressing special causes of process variations (based on the selected product and process attributes)

- Bringing the performance of the process within its natural bounds (i.e., make the process performance statistically stable and predictable based on the selected product and process·attributes)
- Determining the capability of the process to satisfy established quantitative product quality, service quality, and process performance objectives
- Taking appropriate corrective actions when it is determined that the established quantitative product quality, service quality, and process performance objectives will not be satisfied

These corrective actions may be limited to merely changing the objectives or ensuring that the stakeholders concerned about the objective have a quantitative understanding of, and have agreed to, the performance shortfall. At this capability level, these actions do not need to produce improvements that achieve the established quantitative objectives.

Level 4 Generic Goals

Institutionalize a Quantitatively Managed Process The process is institutionalized as a quantitatively managed process.

Level 4 Generic Practices

Establish Quality Objectives

Establish and maintain quantitative objectives for product quality, service quality, and process performance based on customer needs and business objectives.

The purpose of this practice is to determine and obtain agreement from affected stakeholders on specific quantitative objectives for product quality, service quality, and process performance.

The quantitative objectives may be specific to the individual process or they may be defined at a higher level (i.e., for a set of processes), with the individual processes contributing to achieving these objectives. Quantitative objectives that are specific to the individual process are typically allocated from quantitative objectives established at a higher level.

These quantitative objectives are criteria used to judge whether the products, services, and process performance will satisfy the customers, end users, organization's management, and process implementers. These quantitative objectives referred to here go beyond the traditional end-product objectives. They also cover intermediate objectives that are used to manage the achievement of the objectives throughout the life cycle. These quantitative objectives should be set to values that are likely to be achieved when the processes involved are stable and within their natural bounds.

Quantitatively Manage Process Performance

Quantitatively manage the performance of the process to determine its capability to achieve the established quantitative product quality, service quality, and process performance objectives.

The purpose of this practice is to stabilize the performance of the process using appropriate statistical and other quantitative techniques so that the ability to achieve established quantitative product quality, service quality, and process performance objectives can be predicted with reasonable accuracy.

The quantitative objectives may be specific to the individual process or they may be defined at a higher level (i.e., for a set of processes), with the individual processes contributing to achieving these objectives. Quantitative objectives that are specific to the individual process are typically allocated from quantitative objectives established at a higher level.

Quantitative management is performed on the overall set of processes that produces a product or provides a service. Stabilizing the process performance involves identifying and stabilizing selected processes that are critical to the overall process in terms of achieving the quantitative product quality, service quality, and process performance objectives.

A stable process shows no significant indication of special causes of variation. Stable processes are predictable within the limits established by the natural bounds of the process. Variations in the stable process are due to a constant system of chance causes, and the magnitude of the variations may be small or large.

Determining the capability to achieve the established quantitative objectives requires a quantitative understanding of the contributions of the processes to achieving these objectives and establishing and managing against interim quantitative objectives over the life cycle of the process.

Capability Level 5: Optimizing

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

Process improvements that would address common 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.

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

Selected incremental and innovative technological process improvements are deployed into the organization in a systematic manner. The effects of the deployed process improvements are measured and evaluated against the quantitative process improvement objectives.

An optimizing process is institutionalized by doing the following:

- Satisfying the items that institutionalize a quantitatively managed process
- Establishing and maintaining quantitative process improvement objectives
- Identifying and deploying both incremental and innovative technological improvements that continually improves the range of process performance

Institutionalization also implies that the breadth and depth of implementation of the process and the length of time the process has been in place is appropriate to ensure that it is ingrained as part of the way the work is performed.

A critical distinction between a quantitatively managed process and an optimizing process is the type of process variation addressed. A quantitatively managed process is concerned with addressing special causes of process variation and providing statistical predictability for the results. Though the process may produce predictable results, the results may be insufficient to achieve the established objectives. An optimizing process is concerned with addressing common causes of process variation and changing the process (i.e., shift the mean of the process performance) to improve process performance (while maintaining statistical predictability) in order to achieve the established quantitative process improvement objectives.

A common cause of process variation is a cause that is inherently part of a process and affects the overall performance of the process.

Level 5 Generic Goals

Institutionalize an Optimizing Process The process is institutionalized as an optimizing process.

Level 5 Generic Practices

Establish Process Improvement Objectives

Establish and maintain quantitative process improvement objectives that support the organization's business objectives.

The purpose of this practice is to set specific quantitative objectives for process improvements and to ensure that there is a common understanding within the organization on these objectives.

The quantitative process improvement objectives may be specific to the individual process or they may be defined at a higher level (i.e., for a set of processes), with the individual processes contributing to achieving these objectives. Objectives that are specific to the individual process are typically allocated from quantitative objectives established at a higher level.

These process improvement objectives are primarily derived from the organization's business objectives and from the detailed understanding that is gained from having processes that are quantitatively managed. These objectives are the criteria used to judge whether the process performance is quantitatively improving the organization's ability to meet its business objectives. These process improvement objectives are often set to values beyond the current process performance, and both incremental and innovative technological improvements may be needed to achieve these objectives. These objectives may also be revised frequently to continue to drive the improvement of the organization's processes (i.e., when a objective is achieved, it may be set to a new value that is again beyond the new process performance).

Address Common Cause of Problems

Identify and address the root causes of actual and potential defects and other problems in the process.

The purpose of this practice is to analyze defects and other problems that were encountered, to take action to address the root cause of these types of defects and problems, and to prevent these defects and problems from occurring in the future.

Identify Process Improvements

Identify process improvements that would result in significant and measurable improvements to process performance.

The purpose of this practice is to identify those process improvements that directly apply to the organization's processes and that would help achieve the organization's quantitative process improvement objectives.

Process improvements include both incremental changes and innovative technological improvements. The innovative technological improvements are typically pursued as efforts that are separately planned, performed, and managed. Piloting is often performed. These efforts often address specific areas of the processes that are determined by analyzing the process performance and identifying specific opportunities for significant measurable improvement.

Deploy Improvements

Define strategies and manage deployment of selected process improvements based on the quantified expected benefits, the estimated costs and impacts, and the measured change to process performance.

The purpose of this practice is to continually improve the organization's processes by deploying improvements (both incremental changes and significant innovations) in a systematic manner. The costs and benefits of these improvements are estimated quantitatively, and the actual costs and benefits are measured. Benefits are primarily considered relative to the organization's quantitative process improvement objectives. Improvements are made to both the organization's set of standard processes and the defined processes.

Managing deployment of the process improvements includes piloting of changes where appropriate, addressing potential and real barriers to the deployment, minimizing disruption to ongoing efforts, and managing risks.

Process Areas
Normative Model

ORGANIZATIONAL PROCESS FOCUS

Process Management

The purpose of Organizational Process Focus is to establish and maintain an understanding of the organization's processes and process assets, build an infrastructure to support their use, and plan and coordinate the organization's process improvement activities.

Specific Practices by Goal:

Goal 1. **Determine Process Improvement Opportunities**

Strengths, weaknesses, and improvement opportunities for the organization's processes are identified.

SP 1. **Determine Organizational Process Needs**

Establish and maintain the description of the process needs and objectives for the organization.

SP 2. **Assess the Organization's Processes**

Assess the processes of the organization to maintain an understanding of their strengths and weaknesses.

SP 3. **Identify the Organization's Process Improvements**

Identify improvements to the organization's processes and related process assets.

Goal 2. **Coordinate Process Improvement Activities**

Definition, improvement, and deployment of the process assets are coordinated across the organization.

SP 1. **Plan Process Improvement Actions**

Establish and maintain action plans to address improvements to the organization's processes and related process assets.

SP 2. Implement Process Actions

Coordinate implementation of the process action plans across the organization.

SP 3. Deploy Process Assets

Coordinate deployment of the organization's process assets.

SP 4. Capture Process-Related Experiences

Incorporate process-related work products, measures, and improvement information derived from planning and performing the process into the organization's process assets.

ORGANIZATIONAL PROCESS DEFINITION

Process Management

The purpose of Organizational Process Definition is to establish and maintain a usable set of organizational process assets.

Specific Practices by Goal:

Goal 1. Define Processes

Organizational process assets used to establish and maintain the organization's defined processes are available.

SP 1. Establish standard processes

Establish and maintain the organization's set of standard processes.

SP 2. Life-Cycle Model Descriptions

Establish and maintain descriptions of the life-cycle models approved for use in the organization.

SP 3. Establish Tailoring Guidelines

Establish and maintain the tailoring guidelines for the organization's set of standard processes

Goal 2. Implement Processes

Process assets that support the use of the organization's set of standard processes are available.

SP 1. Establish An Organizational Support Environment

Establish and maintain the support environment needed to perform the organization's processes.

SP 2. Establish An Organizational Measurement Repository

Establish and maintain the organization's measurement repository.

2557 **SP 3. Establish An Organizational-Process Asset Library**

2558 Establish and maintain the organization's library of process-related
2559 assets.

ORGANIZATIONAL TRAINING

Process Management

The purpose of Organizational Training is to develop the skills and knowledge of people so they can perform their roles effectively and efficiently.

Specific Practices by Goal:

Goal 1. **Make Training Available**

Training to support the organization's management and technical roles is available.

SP 1. **Identify Strategic Training Needs**

Identify the strategic training needs of the organization.

SP 2. **Identify Organization-Level Training**

Determine which training needs will be addressed at an organizational level.

SP 3. **Establish Training Infrastructure**

Establish and maintain training to address organizational training needs.

Goal 2. **Provide Necessary Training**

Individuals receive the training they need to perform their roles.

SP 1. **Deliver Training**

Train the people following an organizational training plan.

SP 2. **Keep Records**

Keep training records for the organization.

2584 **SP 3. Assess Effectiveness**

2585 Assess the effectiveness of the organization’s training program.

QUANTITATIVE MANAGEMENT OF QUALITY AND PROCESS

Process Management

The purpose of the Quantitative Management of Quality and Process process area is to quantitatively manage the project's defined process to achieve the project's established quality and process performance requirements and objectives.

Specific Practices by Goal:

Goal 1. **Quantitatively Manage the Process**

The ability of the project's defined process to achieve the project's quality and process performance objectives is quantitatively managed.

SP 1. **Establish the Project's Objectives**

Establish and maintain the project's quality and process performance objectives.

SP 2. **Manage performance of the project's defined process**

Determine whether the project's defined process is able to satisfy the project's objectives, and take corrective action as appropriate.

Goal 2. **Statistically Manage the Subprocesses**

The performance of selected subprocesses of the project's defined process is statistically managed.

SP 1. **Use Data When Composing the Defined Process**

Identify the subprocesses that compose the project's defined process based on historical stability and capability data.

SP 2. **Select the Subprocesses to be Managed**

Select the subprocesses of the project's defined process that will be statistically managed.

SP 3. Select Measures and Analytic Techniques

Select the measures and analytic techniques to be used in statistically managing the selected subprocesses.

SP 4. Achieve Statistical Control of the Subprocesses

Establish and maintain statistical control of the selected subprocesses using the selected measures and analytic techniques.

SP 5. Manage Subprocess Capability

Determine whether the selected subprocesses are capable of satisfying their quality and process performance objectives, and take corrective action as necessary.

SP 6. Record Statistical Management Data

Record statistical and quality management data in the organization's measurement repository.

ORGANIZATIONAL PROCESS PERFORMANCE

Process Management

The purpose of Organizational Process Performance is to provide the organizational data, baselines, and models to support quantitatively managing the organization's and project's processes.

Specific Practices by Goal:

Goal 1. Establish Performance Baselines and Models

Baselines and models that characterize the expected process performance of the organization's set of standard processes are established and maintained.

SP 1. Select Processes

Select the processes or process elements in the organization's set of standard processes that are to be included in the organization's process performance analyses.

SP 2. Define Measures

Establish and maintain definitions of the measures that are to be included in the organization's process performance analyses.

SP 3. Process Performance Objectives

Establish and maintain quantitative process performance objectives for the organization.

SP 4. Establish Performance Baselines

Establish and maintain the organization's process performance baselines.

SP 5. Establish Performance Models

Establish and maintain the process performance models for the organization's set of standard processes.

CAUSAL ANALYSIS AND RESOLUTION

Process Management

The purpose of Causal Analysis and Resolution is to improve process performance and product results by identifying causes of defects and other problems, and taking action to prevent them from occurring in the future.

Specific Practices by Goal:

Goal 1. Determine Causes of Defects

Root causes of defects and other problems are systematically determined.

SP 1. Analyze Defect Data

Analyze data on defects and other problems in the processes and associated work products.

SP 2. Analyze Causes

Perform causal analysis of selected defects and other problems and propose actions to address them.

Goal 2. Address Causes of Defects

Root causes of defects and other problems are systematically addressed to prevent their future occurrence.

SP 1. Implement the Action Proposals

Implement the selected action proposals that were developed from the causal analysis meetings.

SP 2. Evaluate the Impact of Changes

Evaluate the impact of changes on process performance.

SP 3. Record Data

Record causal analysis and resolution data for use across the project and organization.

SP 4. Provide Feedback

Provide feedback to the project and organization on the activities and results of causal analysis and resolution activities.

ORGANIZATIONAL PROCESS TECHNOLOGY INNOVATION

Process Management

The purpose of Organizational Process Technology Innovation is to identify process improvements that would measurably improve the organization's processes. The improvements support the organization's process improvement objectives as derived from the organization's business objectives.

Specific Practices by Goal:

Goal 1. **Identify Potential Improvements**

Incremental and innovative process improvements are identified.

SP 1. **Establish Improvement Objectives**

Establish and maintain quantitative process improvement objectives for the organization.

SP 2. **Improvement proposal collection and analysis**

Collect and analyze process improvement proposals.

SP 3. **Identify Innovations**

Identify innovative improvements that would increase the organization's process performance.

Goal 2. **Evaluate Impact of Potential Improvements**

The impact of potential process improvements on the organization's process performance is evaluated.

SP 1. **Perform cost/benefit analysis**

Analyze the costs and benefits of potential process improvements and their effects on organizational process performance.

SP 2. Perform pilot

Pilot selected process improvements.

SP 3. Select Candidate Improvements

Select process improvement proposals that are candidates for deployment across the organization.

SP 4. Provide Feedback

Provide feedback to the organization on the status and results of the organization's process improvement activities.

PROCESS INNOVATION DEPLOYMENT

Process Management

The purpose of Process Innovation Deployment is to continually and measurably improve the organization's processes by systematically transitioning incremental and innovative improvements into use.

Specific Practices by Goal:

Goal 1. **Deploy the Improvement**

Measurable improvements to the organization's processes are continually and systematically deployed.

SP 1. **Evaluate Candidate Improvements**

Evaluate candidate improvements for deployment across the organization.

SP 2. **Select Improvements for Deployment**

Select the process improvements that will be deployed across the organization.

SP 3. **Plan the Deployment**

Establish and maintain the plans for deploying the selected process improvements.

SP 4. **Manage the Deployment**

Manage the deployment of the selected process improvements.

SP 5. **Measure the Improvements**

Measure the effects of the deployed process improvements.

SP 6. Establish and Maintain Records

Establish and maintain records of the organization's process improvement deployment activities.

SP 7. Provide Feedback

Provide feedback to the organization on the status and results of the process improvement deployment activities.

PROJECT PLANNING

Project Management

The purpose of Project Planning is to establish and maintain plans that define project activities.

Specific Practices by Goal:

Goal 1. Establish Estimates

Estimates of project planning parameters are established and maintained.

SP 1. Establish Projects Tasks and Responsibilities

Establish and maintain project tasks and responsibilities (e.g., a work breakdown structure) that identify and organize the logical units of work to be managed.

SP 2. Estimate Project Attributes

Estimate the attributes (e.g., size or complexity) of the work products and tasks that will be used to determine effort hours, cost, and schedule.

SP 3. Determine Effort and Cost

Use historical data or models to determine the project effort and cost from work product and task attributes.

Goal 2. Develop Project Plans

Project plans are established and maintained

SP 1. Define Project Life Cycle

Define the project life cycle to consist of phases of manageable size.

SP 2. Establish and maintain schedules

Establish and maintain the project's schedule, including task dependencies.

SP 3. Establish Subordinate Plans

Establish and maintain subordinate plans that support the overall project plan.

SP 4. Identify Project Risks

Identify and analyze project risks.

SP 5. Plan for Needed Knowledge and Skills

Plan for knowledge and skills needed to perform the project.

SP 6. Plan for Collection of Project Data

Plan for the definition, collection, and analysis of project progress and performance data.

SP 7. Establish Plan Content

Establish and maintain plans.

Goal 3. Obtain Commitment to the Plan

Commitments to the project plan are established and maintained.

SP 1. Reconcile Work and Funding Levels

Reconcile the plan to reflect available and projected resources.

SP 2. Coordinate Plan Commitment.

Coordinate plans and obtain commitment from individuals and organizations responsible for performing and supporting plan execution.

SP 3. Coordinate Plans with Stakeholders

Conduct stakeholder reviews of project plans and related higher and lower level plans to assess and coordinate plan consistency and dependencies, and obtain stakeholder input.

PROJECT MONITORING AND CONTROL

Project Management

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

Specific Practices by Goal:

Goal 1. **Track Project Performance**

Actual performance of the project is tracked against the estimates for the planning parameters.

SP 1. **Track Product and Task Attributes**

Track the actual work and product and task attributes.

SP 2. **Track Project Performance**

Track the project's progress and performance.

Goal 2. **Monitor the Project**

Progress and issues are monitored and evaluated against the project plan.

SP 1. **Monitor Critical Facilities**

Monitor the facilities that are critical to success of the project.

SP 2. **Monitor Commitments**

Monitor commitments against those documented in the project plan.

SP 3. **Monitor Project Risks**

Monitor and record risks and risk activities.

SP 4. Review Progress

Periodically review the project's technical progress, performance, and issues.

SP 5. Conduct Milestone Reviews

Review the accomplishments and results of the project at selected project milestones.

Goal 3. Take Corrective Action

Corrective actions are taken when the project's performance or results deviate significantly from the plan.

SP 1. Take Corrective Action

Take corrective action as necessary when issues are identified or progress differs significantly from that planned.

SP 2. Revise the Project Plan

Revise the project plan to reflect accomplishments, progress, changes, and corrective actions as appropriate.

SUPPLIER AGREEMENT MANAGEMENT

Project Management

The purpose of Supplier Agreement Management is to manage the acquisition of products and services from sources external to the project

Specific Practices by Goal:

Goal 1. Select Suppliers

Supplers and products are selected to satisfy project requirements.

SP 1. Acquire Off-the-Shelf Products

Select off-the-shelf products to satisfy the project's requirements.

SP 2. Select Suppliers

Select suppliers based on an evaluation of their ability to meet the specified requirements.

Goal 2. Establish Agreements

Agreements with the suppliers are established and maintained.

SP 1. Determine Needs

Determine needs to be fulfilled by sources outside the project.

SP 2. Establish and Maintain Requirements

Establish and maintain project requirements for the products being acquired.

SP 3. Establish and Maintain Agreements

Establish and maintain supplier agreements that provide the supplier with project needs, expectations, and measures of effectiveness.

Goal 3. Monitor Performance

The supplier's performance and results are monitored to ensure that the agreement is met.

SP 1. Monitor and Evaluate Performance

Monitor and evaluate the supplier's progress and performance against the supplier agreement.

SP 2. Perform Reviews

Conduct periodic informal and formal reviews with the supplier as specified in the supplier agreement.

Goal 4. Accept and Transition Products

The project accepts and transfers products from the supplier.

SP 1. Conduct Acceptance Testing

Conduct acceptance reviews and tests and configuration audits for the acquired products prior to their being accepted.

SP 2. Transition Products

Monitor the transition of acquired products from the supplier to the project.

INTEGRATED PROJECT MANAGEMENT

Project Management

The purpose of Integrated Project Management is to manage the project according to an integrated and defined process that is tailored from the organization's set of standard processes. It ensures that the various functions and disciplines associated with the project effectively communicate, coordinate, and collaborate to satisfy the customer's needs.

Specific Practices by Goal:

Goal 1. **Use A Defined Process**

The project is conducted using a defined process that is tailored from the organization's set of standard processes.

SP 1. **Establish a Defined Process**

Establish and maintain the project's defined process.

SP 2. **Incorporate the Defined Process**

Establish and maintain a project plan that incorporates the project's defined process.

Goal 2. **Coordinate Management Activities**

Project management utilizes the organizational functions.

SP 1. **Manage Using Assets**

Manage the project using the project plan and the organization's process assets.

SP 2. **Contribute to Assets**

Contribute work products, measures, and documented experiences to the organization's process assets.

Goal 3. **Coordinate Technical Activities**

Technical activities are coordinated with other project and organizational functions.

SP 1. Participate in Technical Activities

Ensure all appropriate project functions participate in the technical activities.

SP 2. Manage Dependencies

Participate with other project and organizational functions to identify, negotiate, and track critical dependencies.

SP 3. Resolve Coordination Issues

Resolve technical issues with other project and organizational functions.

RISK MANAGEMENT

Project Management

The purpose of risk management is to identify potential problems before they occur, so that risk handling activities may be planned and invoked as needed to mitigate adverse impacts on achieving objectives.

Specific Practices by Goal:

Goal 1. **Develop Risk Management Strategy**

The requirements and strategy for risk management are defined.

SP 1. **Determine sources and categories**

Determine risk sources and categories.

SP 2. **Define Parameters**

Define the parameters used to categorize risks and the parameters used to control the risk management effort.

Goal 2. **Analyze Risks**

Risks are analyzed to determine their relative importance.

SP 1. **Identify Risks**

Identify the risks.

SP 2. **Assess Risks**

Assess likelihood and consequence for each risk.

Goal 3. **Mitigate Risks**

Risks are handled to mitigate adverse impacts on achieving objectives.

SP 1. Develop Mitigation Plans

Develop a risk mitigation plan for each risk.

SP 2. Implement Mitigation Plans

Monitor each risk status and implement the risk mitigation plan as appropriate.

REQUIREMENTS MANAGEMENT

Engineering

The purpose of Requirements Management is to maintain the project's product or component requirements and keep the project's plans, activities, and work products consistent with them.

Specific Practices by Goal:

Goal 1. Maintain Requirements

Requirements are maintained and accurately reflected in project plans, activities and products.

SP 1. Obtain Requirements

Receive the requirements and analyze their quality.

SP 2. Manage Requirements Changes (Level 2)

Formally control and manage changes to requirements, considering impact prior to commitment to change, gaining stakeholder buy in, and tracking and closing out the actions and results.

SP 3. Maintain Requirements Traceability (Level 2)

Maintain the traceability of requirements to their source requirements

SP 4. Track Work Effort Against Requirements

The project controls changes to the requirements as they evolve over the product life cycle and ensures that plans, activities, and work products are kept consistent with the requirements.

CUSTOMER AND PRODUCT REQUIREMENTS

Engineering

The purpose of Customer and Product Requirements is to produce customer and product requirements and a preliminary functional architecture.

Specific Practices by Goal:

Goal 1. **Collect and Translate Needs into Customer Requirements**

Stakeholder needs, expectations, and constraints are collected and translated into mutually agreed to customer requirements.

SP 1. Collect Stakeholder Needs

Identify and collect stakeholder needs, expectations, and constraints.

SP 2. Elicit Needs (Level 2)

Elicit stakeholder needs, expectations, and constraints.

SP 3. Transform Stakeholder Needs, Expectations, and Constraints into Customer Requirements

Transform stakeholder needs, expectations, and constraints into customer requirements and requirements for the verification and validation processes.

SP 4. Obtain Agreement

Obtain agreement between the acquirer and developer on customer requirements.

SP 5. Develop Operational Concepts and Scenarios

Develop operational concepts and scenarios, and analyze and review them to refine and discover new requirements, needs, and constraints.

SP 6. Validate Customer Requirements (Level 3)

Validate customer requirements to ensure they satisfy the customer's operational need.

SP 7. Perform Quantitative Validation of Customer Requirements (Level 4)

Perform quantitative analyses, simulations or prototypes to ensure that customer requirements will satisfy stakeholder needs and expectations.

Goal 2. Refine the Problem

The customer requirements are refined and elaborated to formulate product requirements and a preliminary functional architecture.

SP 1. Derive Product Requirements

Derive, from the customer requirements, product requirements essential to product effectiveness and detailed operational concepts for the product.

SP 2. Establish a Functional Architecture

Establish and maintain a functional architecture.

SP 3. Reduce Product Cost and Risk (Level 3)

Reduce the cost and risk of product development through analysis, simulations, validated models etc.

SP 4. Identify Internal Interface Requirements

Identify interface requirements between functional partitions or objects.

SP 5. Analyze the Adequacy of Requirements (Level 2)

Analyze derived requirements to ensure that they are necessary and sufficient to meet the objectives of higher-level requirements, and are consistent with the product's functional architecture.

TECHNICAL SOLUTION

Engineering

The purpose of Technical Solution is to transform product requirements into a specification of physical components and interfaces, such that their implementation and integration will satisfy the product requirements; and to create products that satisfy the requirements.

Specific Practices by Goal:

Goal 1. Select A Design

A design is selected by evaluating alternatives against established criteria

SP 1. Extend the Functional Architecture

Perform a functional analysis of the requirements to identify logical or functional partitions (e.g., subfunctions), time-critical dependencies, allocation of requirements to functions, and derived requirements.

SP 2. Identify Design Issues and Criteria (Level 3)

Maintain a process and criteria to identify design choices and issues which should be subject to decision analysis or trade-off studies throughout product design and development.

SP 3. Generate Design Alternatives

Use a structured decision analysis and resolution process to generate alternative designs and establish selection criteria.

SP 4. Develop Design Alternatives and Selection Criteria (Level 3)

Develop design alternatives and selection criteria which consider the following:

- Life cycle cost
- Technical Performance
- Complexity
- Robustness to product operations and the environment

- Product expansion and growth
- Cost drivers
- Technology limitations
- Sensitivity to construction methods and materials
- Risk
- Evolution of requirement drivers and technology

Goal 2. **Establish and Maintain the Product Design**

A design is established and maintained.

SP 1. **Use Effective Design Methods**

Establish and use effective design methods.

SP 2. **Select and document a design**

Select a design and document its components and features.

SP 3. **Establish and Maintain Complete Design Descriptions (Level 3)**

Establish and maintain a design that includes the following:

- A description of design components and their functionality
- Performance, functional, and derived requirement allocations to each design component and their interfaces
- Internal and external interface definitions
- Operational concepts and scenarios for the product and components
- Architectural and design features that are key to upgrades and future products
- Rationale for requirement allocations and design decisions

SP 4. **Evolve Operational Concepts and Scenarios (Level 2)**

Evolve the operational concept and scenarios to a level of detail appropriate to each level of physical decomposition.

SP 5. Assign Component and Interface Requirements

Assign requirements to design components and interfaces.

SP 6. Develop Component Specifications (Level 3)

Fully specify the requirements for each design component in terms of the following:

- Allocation of product performance
- Design constraints
- Fit, form, and function to meet requirements and facilitate production
- Derived requirements that address the cost and performance of other life-cycle phases (e.g., production, operations, disposal), to the extent compatible with business objectives.

SP 7. Define Interfaces

Define internal and external interfaces between design components.

SP 8. Define and Document Interfaces (Level 3)

Completely define internal and external interfaces in terms of established and maintained criteria.

SP 9. Perform Make, Buy, or Reuse Analyses (Level 3)

Evaluate whether the design components should be developed, purchased, or reused based on established criteria and project and organizational objectives.

SP 10. Manage Requirement and Design Issues (Level 3)

Conduct an ongoing process for identifying and managing architectural, design, and requirement issues.

SP 11. Evaluate the design (Level 3)

Analyze the design for its ability to meet functional and performance requirements, through appropriate methods available prior to implementation such as analysis, prototyping, modeling or simulation.

Goal 3. **Build and Deliver the Product**

Components are built from the design.

SP 1. **Implement the Design**

Implement the designed components.

SP 2. **Establish and Maintain Product Support Documentation**

Establish and maintain the end-user documentation.

PRODUCT INTEGRATION

Engineering

The purpose of Product Integration is to assemble the product and to ensure that product elements function as a whole.

Specific Practices by Goal:

Goal 1. Develop an Integration Strategy

Integration strategy, requirements and preparation activities are established and maintained.

SP 1. Establish and Maintain an Integration Strategy

Develop an integration strategy and integration requirements.

SP 2. Select the Optimum Integration Strategy (Level 3)

Select the optimum sequence for the integration.

SP 3. Establish and Maintain Coordination of Integration Activities (Level 2)

Coordinate integration activities when multiple teams are involved with product development.

Goal 2. Establish and Maintain Interfaces

The interfaces are coordinated and maintained.

SP 1. Coordinate Interfaces

Coordinate interface definition, design, and changes between affected groups and individuals throughout the life cycle.

SP 2. Review Interface Descriptions for Completeness

Review interface descriptions for coverage and interface data for completeness; also periodically review the adequacy of interface documentation.

SP 3. Control Interface Changes

Maintain the interface descriptions established in the requirement and design process.

Goal 3. Assemble, Test, and Integrate Product Elements

Product elements are assembled and tested, and the integrated product is delivered.

SP 1. Establish and Maintain the Integration Environment

Verify that the integration environment complies with the defined specifications.

SP 2. Inspect Product Elements Upon Receipt

Inspect, when received, each product element required to assemble the product to ensure that it is correct and in good condition.

SP 3. Verify Interface Compliance

Verify that the product element interfaces comply with the interface documentation prior to assembly.

SP 4. Assemble Product Elements

Assemble product elements according to the integration plan.

SP 5. Checkout Assembled Product Elements

Checkout assembled product elements.

SP 6. Perform Acceptance Tests

Establish and maintain the acceptance tests, perform the acceptance tests, and document the acceptance test results.

SP 7. Package and Deliver the Product

Package the assembled product and deliver it to the customer as appropriate.

PRODUCT VERIFICATION

Engineering

The purpose of Product Verification is to assure that work products meets the specified requirements.

Specific Practices by Goal:

Goal 1. **Plan and Prepare for Verification**

Requirements, strategies and preparation activities for verification are established and maintained.

SP 1. **Establish and maintain requirements and strategies for work product verification**

Identify or develop the requirements, methods, processes, and evaluation criteria for verification of selected work products.

SP 2. **Conduct Detailed Preparation Activities (Level 3)**

Identify all necessary verification provisions to embed requirements, design, and development plans in products and services, and establish the verification environment.

SP 3. **Plan Work Product Inspections (Level 2)**

Prepare for the inspection of work products.

Goal 2. **Verify Work Products**

Work products are verified against their specified requirements.

SP 1. **Perform Verification**

Perform verification according to the plans.

SP 2. **Perform Work Product Inspections**

Perform work product inspections on selected work products and record the data.

SP 3. Analyze Verification Results and Take Corrective Action

Analyze the results of all verification activities and propose corrective action

SP 4. Perform Re-Verification

Perform re-verification of corrected deficiencies and changed requirements and designs.

VALIDATION

Engineering

The purpose of Validation is to confirm that a product fulfills its intended use when placed in its intended environment.

Specific Practices by Goal:

Goal 1. Plan and Prepare for Work Product Validation

Requirements, strategies and preparation activities for validation are established and maintained.

SP 1. Establish and Maintain Requirements and Strategies for Performing Validation

Establish and maintain a validation strategy with the involvement of the developers, customers, and end users.

SP 2. Prepare for Requirements Validation

Acquire or develop the environment needed to support product requirements validation.

SP 3. Prepare Validation Environment (Level 2)

Acquire or develop the environment needed to support validation.

SP 4. Define Detailed Acceptance Tests (Level 3)

Define detailed acceptance test cases and procedures.

Goal 2. Validate Work Products

Product requirements and products are validated against their operational needs.

SP 1. Validate Requirements

Conduct product requirements validation

SP 2. Perform Operational Testing

Perform operational evaluations according to an agreed to validation plan.

SP 3. Test and Validate Maintenance, Training and Support Services

Test and evaluate maintenance, training, and support against an agreed to validation plan.

SP 4. Assess Validation Results

Assess validation results and issues for their impact on the project.

SP 5. Involve Stakeholders (Level 2)

Involve the customer (and end users if appropriate) of all products in the review of validation results and issues.

SP 6. Identify Needed Corrective Actions (Level 2)

Identify needed corrective actions.

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CONFIGURATION MANAGEMENT

Support

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

Specific Practices by Goal:

Goal 1. Establish and Maintain Baselines

Baselines of identified work products are established and maintained.

SP 1. Identify Configuration Items

Identify the configuration items, and the work products comprising them, that will be placed under configuration management.

SP 2. Establish and Maintain a Configuration Library

Establish and maintain a library of controlled work products.

SP 3. Build Baselines

Build baselines for internal use and for delivery to the customer.

SP 4. Perform Configuration Audits

Perform configuration audits as appropriate.

Goal 2. Track and Control Changes

Changes to the work products under configuration management are tracked and controlled.

SP 1. Establish and Maintain the Change Request System

Establish and maintain a system to track change requests.

SP 2. Control Changes

Control changes to the content of configuration items.

Goal 3. Communicate Status

The status of work products under configuration management is communicated to affected individuals and groups.

SP 1. Establish and Maintain Configuration Management Records

Establish and maintain records describing configuration items

SP 2. Report Configuration Management Status

Periodically report the results of configuration management activities to affected individuals and groups.

DATA MANAGEMENT

Support

The purpose of Data Management is to provide administrative management of appropriate project data and maintain its availabliity to the project staff and stakeholders.

Specific Practices by Goal:

Goal 1. Develop a Data Strategy

A detailed strategy for the management of data is developed.

SP 1. Establish Master Data Requirements

Establish and maintain a master list of data to be managed with standard requirements for data content and format

SP 2. Establish Privacy Requirements

Establish requirements and procedures to ensure privacy and security of the data.

SP 3. Establish Data Access

Establish a mechanism to access archived data.

Goal 2. Manage Data

Project data are managed with appropriate administrative oversight.

SP 1. Provide Notification

Alert individuals having responsibility for the generation of data of upcoming milestones and delivery dates.

SP 2. Inspect the Data

Inspect the managed data to ensure its compliance with all the data requirements prior to archiving or delivery.

SP 3. Archive the data

Archive the project data.

SP 4. Distribute Data

Make managed data available to the project and other parts of the organization as specified in the data management plan.

SP 5. Provide Status

Provide reports documenting status of project data and data management activities to appropriate groups or individuals.

PROCESS AND PRODUCT QUALITY ASSURANCE

Support

The purpose of Process and Product Quality Assurance is to objectively review activities and work products for their adherence to applicable requirements, process descriptions, standards, and procedures, and communicate the results to staff and management.

Specific Practices by Goal:

Goal 1. **Objectively Verify Activities, Work Products, and Services**

Adherence of the work products, services, and activities to applicable requirements, process descriptions, and standards are objectively verified.

SP 1. **Review Activities**

Objectively review and evaluate the designated activities against the applicable requirements, process descriptions, and standards.

SP 2. **Review Work Products and Services**

Objectively review and evaluate the designated work products and services against the applicable requirements and standards.

SP 3. **Report Results**

Periodically report to those affected the results of the Process and Product Quality Assurance activities.

Goal 2. **Escalate Identified Noncompliance issue**

Identified non-compliance issues are escalated as necessary for resolution.

SP 1. **Resolve Noncompliance Issues**

Resolve non-compliance issues identified in the activities, work products, and services in collaboration with the staff and managers.

MEASUREMENT AND ANALYSIS

Support

The purpose of Measurement and Analysis is to develop and sustain a measurement capability in support of management information needs.

Specific Practices by Goal:

Goal 1. Align Measurement and Analysis Activities

Measurement objectives and practices are aligned with established information needs and objectives.

SP 1. Establish Measurement Objectives

Establish and maintain measurement objectives.

SP 2. Define Measures

Identify and define specific measures to address the high-level measurement objectives.

SP 3. Define Data Collection and Storage Procedures

Define how measures will be obtained (produced and collected) and stored.

SP 4. Define Analysis Procedures

Define how measures will be analyzed and reported.

Goal 2. Provide Measurement Results

Measurement results that address information needs are available.

SP 1. Collect Measurement Data

Obtain measurement data.

SP 2. Analyze Measurement Data

Analyze and interpret measurement data.

SP 3. Store Data and Results

Manage and store data, measurement definitions, and results.

SP 4. Communicate Results

Report results of measurement and analysis activities to appropriate end users.

DECISION ANALYSIS AND RESOLUTION

Support

The purpose of Decision Analysis and Resolution is to identify alternatives to issues that have a significant impact on meeting objectives, analyzing the alternatives, and selecting one or more alternatives that best support prescribed objectives.

Specific Practices by Goal:

Goal 1. Establish and Use Criteria to Identify Issues for Formal Analysis

Criteria are established and used to determine which issues are to be subjected to a formal decision analysis and resolution process.

SP 1. Collect Issues

Collect issues that may affect the accomplishment of prescribed objectives.

SP 2. Establish and Use Criteria for Decision Analysis

Establish and use criteria to determine which issues are subject to a formal decision analysis and resolution process.

Goal 2. Select Alternatives

Solutions to selected issues are based on an evaluation of alternatives against established criteria.

SP 1. Identify Alternatives.

Elicit alternative solutions to issues.

SP 2. Select Decision-Making Techniques

Select appropriate decision-making techniques.

SP 3. Establish Evaluation Criteria

Establish evaluation criteria and their relative weights.

SP 4. Evaluate and Document Assumptions (Level 2)

Evaluate assumptions related to selection criteria and evidence that supports the assumptions.

SP 5. Evaluate Sensitivity (Level 2)

Evaluate whether small changes in criteria or their weights would affect the evaluation and revise criteria, as appropriate.

Goal 3. Select and Communicate Solutions

Solutions are selected and communicated to stakeholders.

SP 1. Involve Stakeholders (Level 2)

Involve stakeholders in the selection of solutions.

SP 2. Select Solutions

Select solutions from the alternatives based on the evaluation criteria.

SP 3. Communicate Decisions

Communicate with the stakeholders the decisions and rationale for accepting and rejecting alternatives.

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Acronyms

ARC	Assessment Requirements for CMMI
CAF	CMM Appraisal Framework
CAM	CMMI Assessment Method
CAMF	CMMI Assessment Method Framework
CAR	Causal Analysis and Resolution (process area)
CBA IPI	CMM-Based Appraisal for Internal Process Improvement
CCB	configuration control board
CM	Configuration Management (process area)
CMM	Capability Maturity Model
CMMI	Capability Maturity Model-Integrated
CMMI-SE/SW	Capability Maturity Model-Integrated for Software Engineering and Systems Engineering
CPR	Customer and Product Requirements (process area)
DAR	Decision Analysis and Resolution (process area)
DM	Data Management (process area)
DoD	Department of Defense
EIA/IS	Electronic Industries Association Interim Standard
GP	Generic Practice
IPD-CMM	Integrated Product Development Capability Maturity Model
IPM	Integrated Project Management (process area)
IPT	Integrated Product Team
ISO	International Organization for Standardization

ISO/IEC	International Organization for Standardization and International Electrotechnical Commission
MOA	Memorandum of Agreement
M&A	Measurement and Analysis (process area)
OPD	Organizational Process Definition (process area)
OPF	Organizational Process Focus (process area)
OPP	Organizational Process Performance (process area)
OPTI	Organizational Process Technology Innovation (process area)
OT	Organizational Training (process area)
PA	process area
PAIS	Process Appraisal Information System
PI	Product Integration (process area)
PID	Process Innovation Deployment (process area)
PMC	Project Monitoring and Control (process area)
PP	Project Planning (process area)
PPQA	Product and Process Quality Assurance (process area)
PV	Product Verification (process area)
QMQP	Quantitative Management of Quality and Process (process area)
REQM	Requirements Management (process area)
RSKM	Risk Management (process area)
SAM	Supplier Agreement Management (process area)
SCAMPI	Standard CMMI Assessment Method for Process Improvement
SE-CMM	Systems Engineering Capability Maturity Model
SECAM	Systems Engineering Capability Assessment Model

SECM	Systems Engineering Capability Model
SE/SW	systems engineering and software engineering
SW-CMM	Capability Maturity Model for Software
TS	Technical Solution (process area)
Val	Validation (process area)
WBS	work breakdown structure

3403 # Glossary

ability to perform

A common feature of CMMI model process areas using a staged representation that describes the preconditions that must exist in the project or organization before the system process can be consistently implemented. Ability to perform involves practices (including documenting the process and the plan); resource allocation (including people and tools); assignment authority; and training (including in-depth and overview training). (See also "staged representation" and "process area.")

acceptable alternative practice

A practice that is a substitute for one or more generic or specific practices and that achieves an equivalent effect toward satisfying the goal associated with the generic or specific practices.

acceptance criteria

The criteria that a system or component must satisfy in order to be accepted by a user, customer, or other authorized entity. (See also "system.")

acceptance testing

Formal testing conducted to enable a user, customer, or other authorized entity to determine whether to accept a system or component. (See also "beta testing," "integration testing," "operational testing," "regression testing," and "unit testing" for contrast)

achievement profile

In continuous representations of CMMI models, a list of process areas and their corresponding capability levels that represent the organization’s progress for each process area while climbing up the capability levels. (See "target staging," "capability level profile," "achievement profile," and "target profile.")

allocated requirement

Requirement that levies all or part of the performance and functionality of a higher-level requirement on a function or design component.

alternative practice

A practice that is a substitute for some generic or specific practices contained in the CMMI model. Alternative practices are not necessarily one-for-one replacements for the generic or specific practices.

assessment action plan	A detailed scheme or method to address an assessment finding.
assessment class	A member of a family of assessment methods that satisfy all or a subset of requirements in the Assessment Requirements for CMMI.
assessment finding	The results of an assessment that identify the most important issues, problems, or opportunities for process improvement within the assessment scope.
assessment participants	Members of the assessed organization who participate in providing information during the assessment.
assessment rating	As used in CMMI assessment materials, a characterization of an organization's process relative to a specific CMMI model component that signifies whether that component is satisfied or not satisfied.
assessment reference model	As used in CMMI assessment materials, the CMMI model used by an organization to guide the process improvement efforts; the model to which an assessment team correlates process activities being performed in an assessed organization.
assessment scope	The organizational entities and CMMI model components selected for investigation in the assessment.
assessment sponsor	The individual who authorizes an assessment, defines its goals and constraints, and commits to the use of the assessment results.
assessment team leader	A person who leads the activities of an assessment.
assignable cause of process variation	(See "special cause of process variation.")
audit	In CMMI process improvement work, an independent examination of a work product or set of work products to determine whether requirements are being met.
basic activities of a process	In continuous representations of CMMI models, all of the level one specific practices for any given process area.
beta testing	Testing a pre-release version of the system by making it

	available to selected users. (See also "acceptance testing," "integration testing," "operational testing," "regression testing," and "unit testing." for contrast.)
build	An operational version of a system or component that incorporates a specified subset of the capabilities that the final product will provide.
capability level	Achievement of process improvement within an individual process area. Activities within a capability level are described by generic practices and summarized by generic goals. (See "maturity level" for contrast. See also "process area," generic practice," and "generic goal.")
capability level profile	In continuous representations of CMMI models, a list of process areas and their corresponding capability levels. The profile may be an achievement profile when it represents the organization's progress for each process area while climbing up the capability levels. Or, the profile may be a target profile when it represents an objective for process improvement. (See "target staging," "capability level profile," "achievement profile," and "target profile.")
capability maturity model	A capability maturity model (CMM) for a given discipline is a model that describes the key elements of an effective process for the discipline. It also describes an evolutionary improvement path from an ad hoc, immature process to a disciplined, mature process with improved quality and effectiveness.
capable process	A process that can satisfy its specified product quality, service quality, and process performance objectives. (See "stable process," "standard process," "statistically managed process," and "well-defined process" for contrast.)
change management	Judicious use of means to effect a requirement or design change, or proposed change, on a system, product, or service. (See "configuration management" for contrast.)
CMMI Framework	The basic structure that organizes CMMI products and components, which include common elements and best features of the current CMMI models as well as rules and methods for generating models, their assessment methods (including associated artifacts), and their training materials.
CMMI model	A model that describes the key elements of an effective process for a discipline that is generated from the CMMI Framework and conforms to the framework's rules.

CMMI model component	Any of the main architectural elements that comprise a CMMI model. Some of the main elements of a CMMI model include specific practices, generic practices, specific goals, generic goals, process areas, capability levels, and maturity levels.
CMMI model tailoring	The use of selected portions of a CMMI product, or the selection of options within a CMMI product.
CMMI Product Suite	The set of products produced from the CMMI Framework. (See also "CMMI Framework.")
commitment to perform	A common feature of CMMI model process areas using a staged representation that describes the actions that the organization must take to ensure that the relevant process is established and will endure. Commitment to perform involves practices on organizational policies (to set expectations for process performance) and senior management sponsorship (specifically for organizational process areas). (See also "staged representation" and "process area.")
common cause of process variation	The variation of a process that exists because of normal and expected interactions among the components of a process. (See "special cause of process variation" for contrast.)
competency management	The continuously improving process used to enhance the capability of the staff to perform their assigned tasks and responsibilities, and to achieve specific competency growth objectives.
component requirements	The requirements that are allocated to lower-level components when a higher-level component is decomposed into components. Component requirements provide a complete specification of a component, including fit, form, function, performance, and any other requirement.
concept of operations	(See "operational concept.")
configuration audit	An audit conducted to verify that a configuration item conforms to a specified standard or requirement. (See also "audit" and "configuration item.")
configuration baseline	The configuration information formally designated at a specific time during a product's or component's life cycle. Configuration baselines, plus approved changes from those baselines, constitute the current configuration information. (See also "system life cycle.")

configuration control	An element of configuration management, consisting of the evaluation, coordination, approval or disapproval, and implementation of changes to configuration items after formal establishment of their configuration identification. (See also "configuration management," "configuration identification," and "configuration item.")
configuration control board	A group of people responsible for evaluating and approving or disapproving proposed changes to configuration items, and for ensuring implementation of approved changes. (Configuration control boards are also known as change control boards.) (See also "configuration item.")
configuration identification	An element of configuration management, consisting of selecting the configuration items for a system, assigning unique identifiers to them, and recording their functional and physical characteristics in technical documentation. (See also "configuration management," "configuration item," and "system.")
configuration item	An aggregation of hardware, software, or both, that is designated for configuration management and treated as a single entity in the configuration management process. (See also "configuration management.")
configuration management	A discipline applying technical and administrative direction, and surveillance to identify and document the functional and physical characteristics of a configuration item, control changes to those characteristics, record and report change processing and implementation status, and verify compliance with specified requirements. (See also "configuration item.")
configuration status accounting	An element of configuration management, consisting of the recording and reporting of information needed to manage a configuration effectively. This information includes a listing of the approved configuration identification, the status of proposed changes to the configuration, and the implementation status of approved changes. (See also "configuration management" and "configuration identification.")
configuration unit	The lowest-level configuration entity of a configuration item or component that should be placed into, and retrieved from, a configuration management library system. (See "configuration item" for contrast.)
continuous representation	An instantiation of a capability maturity model wherein capability levels provide a recommended order for

	approaching process improvement within each specified process area. (See "staged representation" for contrast. See also "capability level," and "process area,")
core competency	The knowledge and skills needed within the workforce to perform an important business function of the organization.
corrective action	Acts or deeds used to remedy a situation, remove an error, or adjust a condition.
critical components	Components whose failure or lack of availability result in substantial adverse impacts to system schedule, cost, or system quality. (See also "system.")
critical design review	A review conducted to verify that the detailed design of one or more configuration items satisfies specified requirements; to establish the compatibility among the configuration items and other items of equipment, facilities, software, and personnel; to assess risk. (See also "configuration item.")
customer	The individual or organization responsible for accepting the product and authorizing payment to the developing organization.
customer requirements	A set of client needs to be satisfied by the product. These requirements are agreed to by the customer and supplier and are expressed in the client's terminology. Note: "Customer" as used in this term refers to a client that is external to the supplier that produces the product. In the case of non-negotiated situations, the surrogate for the user or customer is frequently the customer relations or marketing part of the organization. (See "derived requirements," internal customer requirements," product requirements," "programmatic requirements," and "technical requirements" for contrast.)
data management	Identifying, storing, and distributing information, and controlling access to the information base.
defect density	Number of defects per quantifiable product unit (e.g., problem reports per 1000 lines of code, number of hardware failures per 1000 hours, or number defects per transistor).
defined process	A managed process that is tailored from the organization's set of standard processes. Deviations from the managed process beyond those allowed by the tailoring guidelines are documented, justified, reviewed, and approved. A defined process has clearly stated inputs, entry criteria, activities, roles, measures, verification steps, outputs, and exit criteria.

	(See "optimizing process" and "quantitatively managed process" for contrast. See also "entry criteria" and "exit criteria.")
derived requirements	Requirements that are not explicitly stated in the customer requirements, but are inferred (1) from contextual requirements (e.g., applicable standards, laws, policies, common practices, and management decisions), or (2) from requirements needed to specify a design component. Derived requirements can also arise during analysis and design of components of the product or system. (See "customer requirements," "internal customer requirements," "product requirements," "programmatic requirements," and "technical requirements" for contrast.)
design review	A formal, documented, comprehensive, and systematic examination of a design to evaluate the design requirements and the capability of the design to meet these requirements, and to identify problems and propose solutions.
developmental configuration	In configuration management, the evolving product and associated documentation that define the evolving configuration of a configuration item during development. Note: The developmental configuration is under the developer's control, and therefore is not called a baseline. (See also "configuration item," and "configuration management.")
domain analysis	The process of identifying, collecting, organizing, analyzing, and representing the relevant information in a domain-based study of existing systems and their development histories, knowledge captured from domain experts, underlying theory, and emerging technology within the domain. (See also "system.")
effectiveness analysis	An analytical approach to assess how well a design solution will perform or operate given anticipated environments, utilization rates, and operational scenarios. (See also "operational scenario.")
engineering plan	A scheme for guiding, implementing, and controlling the application of science and mathematics to the design and development of useful products. (See also "system life cycle.")
entry criteria	States of being that must be present before an effort can begin successfully.
equivalent staging	In continuous representations, a target staging that is

	equivalent to the maturity levels of the staged representation. Such staging permits benchmarking of progress between organizations, enterprises, and projects. (See "target staging," "capability level profile," and "target profile.")
exit criteria	States of being that must be present before an effort can end successfully.
finding	(see "assessment finding")
formal method	A technique for expressing requirements in a manner that allows the requirements to be studied mathematically. Formal methods allow sets of requirements to be examined for completeness, consistency, and equivalency to another requirement set. Formal methods result in formal specifications.
functional analysis	Examination of a defined function to identify all the sub-functions necessary to the accomplishment of that function; identification of functional relationships and interfaces (internal and external) and capturing these in a functional architecture; and flow down of upper-level performance requirements and assignment of these requirements to lower-level sub-functions. (See also "functional architecture.")
functional architecture	The hierarchical arrangement of functions, their internal and external (external to the aggregation itself) functional interfaces and external physical interfaces, their respective functional and performance requirements, and design constraints. (See also "functional requirements" and "performance requirements.")
functional baseline	The initially approved documentation describing a system's or product's functional performance, interoperability, and interface requirements and the verification required to demonstrate the achievement of those specified requirements.
functional configuration audit	An audit conducted to verify that the development of a configuration item has been completed satisfactorily, that the item has achieved the performance and functional characteristics specified in the functional or allocated configuration identification, and that its operational and support documents are complete and satisfactory. (See also "audit," "configuration item," and "configuration identification.")

generic goal	A goal attained by performing one or more practices that apply to multiple process areas. (See "quantitative objective," "organization's business objectives," "specific goal," and "quality objectives" for contrast.)
generic practice	A practice that is applicable to any process area, does not belong to a specific process area, and is important to stability and improvement within multiple process areas. Examples of generic practices are process planning, training, and work product inspection. (See also "process area.")
incomplete process	A process that is not performed or only performed partially (also known as capability level 0). One or more of the specific goals of the process area are not satisfied.
institutionalization	The building and reinforcement of infrastructure and corporate culture that support methods, practices, and procedures so that they are the ongoing way of doing business, even after those who originally defined them are gone.
integrated product and process development	A management technique that simultaneously integrates all essential system acquisition activities through the use of multidisciplinary teams to optimize the design, manufacturing, and supportability processes. Integrated product and process development facilitates meeting cost and performance objectives from product concept through production, including field support.
integrated product development	A team approach to the systematic development of products, wherein each multidisciplinary team in a project is organized over the product life cycle solely for the development of a given work product, to better satisfy customer needs.
integration testing	Testing in which software components, hardware components, or both are combined and tested to evaluate the interaction between them. (See "acceptance testing," "beta testing," "operational testing," "regression testing," and "unit testing" for contrast.)
interface control	In configuration management, the process of: 1. identifying all functional and physical characteristics relevant to the interfacing of two or more configuration items provided by one or more organizations, and 2. ensuring the proposed

	changes to these characteristics are evaluated and approved prior to implementation. (See also "configuration management" and "configuration item.")
internal customer requirements	Requirements upon a part or component of a system, product, or service that are levied within the organization and are in addition to the system or programmatic requirements. For example, if the organization has specified a standard set of management tools (e.g., Microsoft Project), this would be an internal customer requirement. (See "customer requirements," derived requirements," "product requirements," "programmatic requirements," and "technical requirements" for contrast. See also "system.")
lead assessor	A qualified person who is in good standing and satisfies the requirements of the SEI Appraiser Program and is authorized to use SEI materials in leading assessments.
Lead Assessor	As used in the CMMI Product Suite, a person who is trained and qualified, who satisfies the requirements of the SEI Appraiser Program, and who is authorized to lead a CMMI assessment using CMMI materials.
life cycle model	A partitioning of the life of a product into phases that guide the project from identifying customer needs through product retirement.
managed process	A performed process that is planned, documented, performed, monitored, and controlled at the local level (also known as capability level 2).
maturity level	Degree of process improvement across a predefined set of process areas in which all goals within the set are attained. (See "capability level" for contrast. See also "process area.")
memorandum of agreement	Binding documents of understanding or agreements between two or more parties. (See also "memorandum of understanding.")
memorandum of understanding	Binding documents of understanding or agreements between two or more parties. (See also "memorandum of agreement.")

natural bounds	The inherent process reflected by measures and metrics of process performance, sometimes referred to as "voice of the process." Techniques such as control charts, confidence intervals, and prediction intervals are used to determine whether the variation is due to common causes (i.e., the process is predictable or "stable") or is due to some special cause that can and should be identified and removed.
non-developmental item	An item of supply that was developed and used previous to its current use in an acquisition or development process. Such an item may require minor modifications to meet the requirements of its current intended use.
objective assessment evidence	In CMMI assessments, information that has been witnessed by the assessment team.
objective assessment evidence	As used in CMMI assessment materials, information collected during an assessment that is either heard from a knowledgeable person or seen in a document.
objective review	An evaluation of activities and work products against criteria that minimize subjectivity and bias by the reviewer. An example of an objective review is an audit against requirements, standards, or procedures by an independent quality assurance function. (See also "audit.")
objectively verify	Making sure what is done adheres to standards, policies, plans, requirements, etc. by using techniques that are applied by people who are not directly responsible for managing or performing the activities of the process.
observation	As used in CMMI assessment materials, a statement derived by the assessment team from data received during the assessment.
operational concept	A general description of the way in which an entity is used or operates. (Also known as "concept of operations.)
operational documentation	Usually printed or printable instructions used to install, use, and maintain something.
operational scenario	A description of an imagined sequence of events that includes the interaction of the product with its environment and users, as well as interaction among its components. Operational scenarios are used to evaluate the requirements and design of the system.

operational testing	Testing conducted to evaluate something in its operational environment. (See "acceptance testing," "beta testing," "integration testing," "regression testing," and "unit testing" for contrast.)
optimizing process	A quantitatively managed process that is improved based on an understanding of the common causes of variation inherent in the process. A process that focuses on continually improving the range of process performance through both incremental and innovative improvements. (See "quantitatively managed process" and "defined process" for contrast. See also "common cause of process variation.")
organization's business objectives	The reasons for an organization's existence. Such objectives may include: reducing the number of change requests during a system's integration phase, reducing development cycle time, increasing the number of errors found in a system's first or second phase of development, reducing the number of customer-reported defects, etc., when applied to systems engineering activities. (See "generic goal," "quantitative objective," "specific goal," and "quality objectives" for contrast.)
organization's measurement program	The set of related elements for addressing an organization's measurement needs. This set includes the definition of organization-wide measurements, methods, and practices for collecting organizational measurements and analyzing data, and measurement objectives for the organization.
organization's set of standard processes	The definition of the basic processes that are used as the basis for establishing common process across the organization. It describes the fundamental process elements that are expected to be incorporated into the defined processes. It also describes the relationships (e.g., ordering and interfaces) between these process elements. (See also "defined process" and "process elements.")
organizational policy	A guiding principle, typically established by senior management, which is adopted by an organization or project to influence and determine decisions.
organizational process capability	The capacity of an organization to identify, in statistical terms, its potential for quantitatively managing and executing its processes. (See also "quantitatively managed process.")
organizational process maturity	The measure of how explicit and consistent processes have been an assessment that measures how well processes are

	documented, managed, measured, controlled, and continually improving.
organizational unit	An administrative structure in which people collectively manage one or more projects as a whole, and whose projects share a top-level manager and operate under the same policies. (See also "project.")
peer review	(See "work product inspection.")
performance parameters	The measures of effectiveness and other key metrics used to guide and control progressive development.
performed process	A process that accomplishes the needed work to produce identified output work products using identified input work products (also known as capability level 1). The specific goals of the process area are satisfied.
physical configuration audit	An audit conducted to verify that a configuration item, as built, conforms to the technical documentation that defines it. (See also "audit" and "configuration item.")
planned process	A process that is documented both by a description and a plan. The description and plan should be coordinated, and the plan should include standards, requirements, objectives, resources, assignments, etc.
process action team	A team that has the responsibility to develop and implement process improvement activities for an organization as documented in the process improvement action plan.
process area	A cluster of related practices in an area that, when performed collectively, achieve a set of goals considered important for establishing process capability in that area. (See also "process capability.")
process asset	Anything that the organization considers useful in attaining the goals of a process area. (See also "process area.")
process asset library	A collection of holdings that can be retrieved for use in improving the capability maturity of an organization or project.
process capability	The ability of a process to achieve one or more required goals.
process capability baseline	A documented characterization of the range of expected results that would normally be achieved by following a

	specific process under typical circumstances.
process database	A repository into which all process data are entered. The database contains actual measurement data and related information needed to understand the measurement data and to assess it for reasonableness and applicability. Centralized control of this database ensures that the process data from all programs are permanently retained and protected.
process definition	The act of defining and describing a process. The result of process definition is a process description. (See also "process description.")
process description	A documented expression of a set of activities performed to achieve a given purpose that provides an operational definition of the major components of a process. The documentation specifies, in a complete, precise, and verifiable manner, the requirements, design, behavior, or other characteristics of a process. It also may include procedures for determining whether these provisions have been satisfied. Process descriptions may be found at the activity, project, or organizational level.
process element	The fundamental unit of process description. A process may be defined in terms of subprocesses or process elements. A subprocess can be further decomposed; a process element is not decomposed into finer-grained descriptions.
process group	A collection of specialists that facilitate the definition, maintenance, and improvement of the process(es) used by the organization.
process implementation team	A group within the organization that has the responsibility to realize a process.
process improvement	A program of activities designed to improve the performance and maturity of the organization's processes and the results of such a program.
process improvement goals	A set of target characteristics established to guide the effort to improve an existing process in a specific measurable way either in terms of resultant product characteristics (e.g., quality, performance, conformance to standards, etc.) or in the way in which the process is executed (e.g., elimination of redundant process steps, combining process steps, improving cycle time, etc.). (See "generic goal," "quantitative goal," "organization's business goals," "specific goal," and

	"quality goals" for contrast.)
process maturity	The extent to which a process is explicitly documented, managed, measured, controlled, and continually improved.
process measurement	The set of definitions, methods, and activities used to take measurements of a process and its resulting products for the purpose of characterizing and understanding the process.
process owner	The person (or team) responsible for defining and maintaining a process description. At the organizational level, the process owner is the person (or team) responsible for the description of a standard process; at the project level, the defined process. A process may therefore have multiple owners at different levels of responsibility. (See also "standard process" and "defined process.")
process performance	A measure of actual results achieved by following a process. It is characterized by both process measures (e.g., effort, cycle time, and defect removal efficiency) and product measures (e.g., reliability, defect density, and response time).
process performance baseline	A documented characterization of the actual results achieved by following a process, which is used as a benchmark for comparing actual process performance against expected process performance. (See also "process performance.")
process tailoring	To make, alter, or adapt a process description for a particular end. For example, a project tailors its defined process from the organization's set of standard processes to meet the objectives, constraints, and environment of the project. (See also "process description," "organization's set of standard processes," and "defined process.")
product	Any tangible output or observable outcome of an activity, including those from services. A result of a process that is intended for delivery to a customer or end user.
product baseline	In configuration management, the initial approved technical documentation (including, for software, the source code listing) defining a configuration item during the production, operation, maintenance, and logistic support of its life cycle. (See also "configuration management," and "configuration item.")
product line	A group of products sharing a common, managed set of features that satisfy specific needs of a selected market or

	mission.
product quality objectives	Specific objectives, which if met, provide a level of confidence that the quality of a product is satisfactory. (See "generic goal," "quantitative objective," "organization's business objectives," and "specific goal" for contrast.)
product requirements	A refinement of the customer requirements into the developers' language, making implicit requirements into explicit derived requirements. The developer uses the product requirements to guide the design and building of the product. (See "customer requirements," "derived requirements," "internal customer requirements," "programmatic requirements," and "technical requirements" for contrast.)
program	(1) A project (2) A collection of related projects and the infrastructure that supports them, including objectives, methods, activities, plans, and success measures. (See "project" for contrast.)
programmatic requirements	Those requirements that describe the non-technical contractual aspects of product development. Examples of programmatic requirements include cost, schedule, reports, and reviews. (See "customer requirements," "derived requirements," "internal customer requirements," "product requirements," and "technical requirements" for contrast.)
project	A managed set of interrelated resources that delivers one or more products to a customer or end user. This set of resources has a definite beginning and end and typically operates according to a plan. Such a plan is frequently documented and specifies the product to be delivered or implemented, the resources and funds used, the work to be done, and a schedule for doing the work.
project's defined process	The operational definition of the process as used by a specific project. Well characterized and understandable, it is described in terms of roles, standards, procedures, activities, entry/exit criteria, inputs/outputs, appropriate sequencing, tools, and methods. (See also "defined process," "project," and "organization's set of standard processes.").
project manager	The person responsible for planning, directing, controlling, structuring, and motivating the project. (See also "project.")
project progress and performance	What a project achieves with respect to implementing project plans, including effort, cost, schedule, and technical performance.

prototype	A model (physical, electronic, digital, analytical, etc.) of a product built or constructed for the purpose of, but not limited to: 1. assessing the feasibility of a new or unfamiliar technology, 2. assessing or mitigating technical risk, 3. validating requirements, 4. demonstrating critical features, 5. qualifying a product, 6. qualifying a process, 7. characterizing performance or product features, or 8. elucidating physical principles.
quality	1. The degree to which a system, component, or process meets specified requirements. 2. The degree to which a system, component, or process meets customer or user needs or expectations.
quality assurance	A planned and systematic means for assuring management that defined standards, practices, procedures, and methods of the process are applied.
quality control	The operational techniques and activities that are used to fulfill requirements for quality. (For contrast, see “quality assurance.”)
quality management	All activities of the overall management function that determine the quality policy, objectives, and responsibilities, and implement them by means such as quality planning, quality control, quality assurance, and quality improvement within the quality system.
quality planning	The activities that establish the objectives and requirements for quality and for the application of quality system elements.
quantitative control	Use of appropriate statistical and other quantitative techniques to analyze a process, identify special causes of variations in the performance of the process, and bring the performance of the process well within well-defined limits. (See also "special cause of process variation.")
quantitative objective	Desired target value expressed as quantitative metrics. (See "generic goal," "organization's business objectives," "specific goal," and "quality objectives" for contrast.)
quantitatively managed process	A defined process that is controlled using statistical and other quantitative techniques. The product quality, service quality, and process performance attributes are measurable

	and controlled throughout the life cycle. (See "optimizing process," "defined process," and "statistically managed process" for contrast.)
reference model	A model that is used as a benchmark for measuring some attribute.
regression testing	Testing to determine that a change to a system component has not adversely affected its physical attributes, functionality, reliability, or performance. (See "acceptance testing," "beta testing," "integration testing," "operational testing," and unit testing" for contrast.)
requirements analysis	The determination of system-specific performance and functional characteristics based on analyses of: customer needs, requirements, and objectives; mission or operations; projected utilization environments for people, products, and processes; constraints; and measures of effectiveness.
requirements elicitation	Using systematic techniques, like prototypes and structured surveys, to proactively identify and document customer and end-user needs that are not always immediately recognized by the customer and end user.
requirements traceability	The evidence of an association between a requirement and its parent requirement, its implementation, and its verification.
return on investment	The ratio of revenue from output (product) to production costs, which determines whether an organization benefits from performing an action to produce something.
risk management	An organized, analytic process to identify what might cause harm or loss (identify risks), assess and quantify the identified risks, and to develop and, if needed, implement an appropriate approach to prevent or handle risk causes that could result in significant harm or loss.
risk mitigation strategies	The principles used to identify the activities that might be implemented to mitigate specific risks and identify the order in which risk mitigation activities are implemented.
senior manager	A management role at a high enough level in an organization that the primary focus is the long-term vitality of the organization, rather than short-term project and contractual concerns and pressures. The senior manager has authority to direct the allocation or reallocation of

	resources in support of organizational process improvement effectiveness.
significant weakness	As used in CMMI assessment materials, a weakness that results in the rating of a CMMI model component to be "not satisfied."
software capability evaluation	A CMMI-based appraisal by a trained team of professionals to identify contractors who are qualified to perform the software work or to monitor the state of the software process used on an existing software effort.
software engineering	(1) The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software (2) The study of approaches as in (1).
special cause of process variation	A cause of a defect that is specific to some transient circumstance and not an inherent part of a process. Special causes of variation provide random variation (noise) in process performance. (See "common cause of process variation" for contrast.)
specific goal	A goal that is attained by performing specific practices within a process area. An organization must attain the associated goals of a process area to satisfy its requirements or the requirements of one of its capability levels. (See also "process area" and "capability level." See "generic goal," "quantitative objective," "organization's business objectives," and "quality objectives" for contrast.)
specific practice	A practice contained in a process area that describes an essential activity to, in part or in whole, accomplish a goal of the process area. (See also "process area" and "specific goal.")
stable process	The state in which all special causes of process variation have been removed and prevented from recurring so that only the common causes of process variation of the process remain. (See also "special cause of process variation" and "common cause of variation." See "standard process," "statistically managed process, "well-defined process," and "capable process" for contrast.)
staged representation	A capability maturity model structure wherein attaining the goals of a set of process areas establishes a maturity level; each level must be completed before the next level is attempted. (See "continuous representation" for contrast. See also "process area," and "maturity level.")
stakeholder	A group or individual having an interest or share in an

	undertaking.
standard	Mandatory requirements employed and enforced to prescribe a disciplined uniform approach to development.
standard process	The operational definition of the basic process that guides the establishment of a common process in an organization. It describes the fundamental process elements that are expected to be incorporated into any defined process. It also describes the relationships (e.g., ordering and interfaces) between these process elements. (See "defined process," "organization's set of standard processes," "stable process," "statistically managed process, "well-defined process," and "capable process" for contrast.)
statement of work	A description of all work required to complete a project. (See also "project.")
statistical predictability	The performance of a quantitative process that is controlled using statistical and other quantitative techniques.
statistical process control	Statistically based analysis of a process and measurements of process performance, which will identify common and special causes of variation in the process performance, and maintain process performance within limits. (See also "common cause of process variation" and "special cause of process variation.")
statistical techniques	An analytic technique that employs statistical methods (e.g., statistical process control, confidence intervals, prediction intervals).
statistically managed process	A process that is managed by a statistically based technique in which processes are analyzed, special causes of variation are identified, and performance is contained within well-defined limits. (See "stable process," "standard process," "well-defined process," and "capable process" for contrast. See also "special cause of process variation.")
strength	As used in CMMI assessment materials, implementation of practices which, in the judgment of the assessment team, improve an organization's process capability. Strengths related to CMMI models are effective implementations of one or more of the CMMI model practices or alternative practices.
subprocess	A process that is part of a larger process. (See "process description.")
subsystem	A grouping of items that will perform a logical set of

	functions within a particular end product.
system	A set of interrelated physical and functional parts that provide a capability to satisfy an objective.
system component	A basic part of a system. System components may be personnel, hardware, software, facilities, data, material, services, and or techniques which satisfy one or more requirements in the lowest levels of the functional architecture. System components may be subsystems or configuration items. (See also "system," "subsystem," and "configuration item.")
system design process	A process for converting requirements into design solutions.
system life cycle	The period of time that begins when a system is conceived and ends when the system is no longer available for use.
systems engineering	The interdisciplinary approach governing the total technical effort required to transform a requirement into a system solution. (See also "system.")
target profile	In continuous representations of CMMI models, a list of process areas and their corresponding capability levels that represent an objective for process improvement. (See "target staging," "capability level profile," "achievement profile," and "target profile.")
target staging	In continuous representations of CMMI models, a sequence of target profiles that describe the path of process improvement to be followed by the organization. This target staging must meet two requirements: It must be (1) monotone increasing and (2) admissible. (See "target staging," "capability level profile," "achievement profile," and "target profile.")
technical requirements	Those requirements that describe the technical attributes of an entity. (See "customer requirements," "derived requirements," "internal customer requirements," "product requirements," and "programmatic requirements" for contrast.)
test procedure	Detailed instructions for the set-up, execution, and evaluation of results for a given test case.
trade-off study	An evaluation of alternatives based on criteria and systematic analysis, to select the best alternative for

	attaining determined objectives.
unit testing	Testing of individual hardware or software units or groups of related units. (See "acceptance testing," "beta testing," "integration testing," "operational testing," and "regression testing" for contrast.)
version control	Baselines are established and maintained, and changes to baselines are identified in such a way that it is possible to return to the previous baseline.
weakness	As used in CMMI assessment materials, ineffective implementation of, or lack of, practices which, in the judgment of the assessment team, interfere with effective implementation of a CMMI model component. Weaknesses related to CMMI models are ineffective implementations, or lack of implementation, of one or more of the CMMI model practices with no acceptable alternative practices in place.
well-defined process	A documented, consistent, and complete process that has specified entry criteria, inputs, task descriptions, verification descriptions and criteria, outputs, and exit criteria. (See "defined process," "stable process," "standard process," "statistically managed process," and "capable process" for contrast. See also "entry criteria" and "exit criteria.")
work breakdown structure	An arrangement of work elements and their relationship to each other and to the end product.
work product	Any artifact produced by a process. This includes files, documents, components, work-in-progress, specifications, invoices, and so forth, generated during process performance, not just the product delivered to the process customer or user.
work product and task attributes	Characteristics of products, services, and project tasks used to help in estimating project work. These characteristics include items such as size, complexity, weight, form, fit, or function. They are typically used as one input to deriving other project and resource estimates (e.g., effort, cost, schedule).
work product inspection	The review of work products during their development to identify defects for removal.

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Tailoring Criteria

Tailoring of the CMMI model is defined as the use of a subset of the model for purposes of making it suitable for a specific application.

Tailoring of the CMMI assessment method refers to the selection of options for use in a specific instance. In both cases, the intent of tailoring is to assist an organization or project in aligning the CMMI products with its business needs and objectives, and thus focus on those aspects of the products that are most beneficial.

The tailoring discussed in this section does not address adaptation of an organization's set of standard processes for use on a specific program. Such tailoring is driven by tailoring guidelines defined by an organization and is further addressed in the Integrated Project Management Process Area.

Tailoring should be done with an awareness that it can result in significant gaps in efforts to improve or assess an organization's or project's capabilities.

Model Tailoring Perspectives

Tailoring of the CMMI model can be viewed from two perspectives:

- Tailoring relating to use of the model for process improvement and
- Tailoring related to use of the model for benchmarking purposes.

In fact, many organizations will use the model for benchmarking as well as process improvement, so the appropriate tailoring will be the constrained by the intersection of criteria outlined below.

Model Tailoring Criteria for Internal Process Improvement

For internal process improvement, it is appropriate to restrict the scope of an organization's or project's improvement effort (including assessments) to individual disciplines, process areas, maturity levels and/or capability levels. In this case, tailoring of the model should focus on identifying the subset of process areas and practices that support the business needs and objectives. Given the model's focus on the essential characteristics of an effective process, it would be expected that the majority of the process areas and practices in the model would typically be addressed. In fact, the wisdom of wholesale exclusion of fundamental processes and/or practices (in particular at maturity levels 2 and 3) may be questionable given the prevalence of data indicating that following CMM-based improvement efforts will significantly improve attainment of business objectives. Cited improvements in the literature include the increased likelihood that an organization or project will achieve its cost and/or schedule objectives.

Organizations and/or projects implementing less than a full set of process areas, goals or practices can still achieve significant value from the CMMI model. However, due to the significant interrelationship of model components, exclusion of a significant number of process areas, goals and/or practices may constrain the benefits achieved. In addition, the degree of comparability of assessment results is directly related to the extent to which the model and assessment method have been tailored.

Model Tailoring Criteria for Benchmarking

Use of the CMMI model for benchmarking purposes allows for comparison of process assessment results across industry via state-of-the-practice reports or across a group of organizations such as potential suppliers. In this case, any tailoring applied must ensure consistency in the ratings and/or findings resulting from use of the model in multiple assessments. As a result, model tailoring for benchmarking is significantly constrained, especially in the case where maturity levels resulting from assessments are disseminated publicly for marketing purposes. Model tailoring criteria for benchmarking are defined as follows:

- Process areas are normative and thus may not be excluded (i.e., tailored) other than to delete those which are outside the scope of an assessment. For example, process areas at maturity levels 4 and 5 may be omitted for an assessment focused on maturity level 3 where all process areas for levels 2 and 3 would typically be selected.

- "Not applicable" Process Areas: In some unique circumstances, an entire process area may be deleted if it is determined to be inapplicable. Typically, very few process areas would be eligible for exclusion in this manner. A good example of a process area that might be excluded would be Supplier Agreement Management, a process area that may be inapplicable in the absence of suppliers.
- Goals, like Process Areas, are normative and thus not excludable for those process areas included in the scope of a process improvement or assessment effort. Goals reflect the minimum requirements for satisfying a process area or capability level and, as such, are required. However they may, like process areas, be determined during an assessment to be not applicable to the organization or project being assessed.
- Specific Practices (SPs) and Generic Practices (GPs) are not normative, but are expected to be implemented as typical activities necessary to implement and institutionalize the goals. However, appropriate alternative practices may be substituted for SPs and/or GPs provided that the alternatives are effective in implementing and institutionalizing the goals. In some cases, SPs and/or GPs may be determined during an assessment to be not applicable and thus excluded from coverage during an assessment.
- All other model components (subpractices, examples, amplifications, elaborations and/or cross-references) contained in Volume II are informative and are provided solely for guidance in implementation.

Assessment Tailoring Criteria

The major tailoring options for a CMMI assessment include:

- Establishing the assessment scope, including the organizational entity to be assessed, the subset of CMMI process areas to be investigated, and the capability level to be assessed
- Selecting the assessment team
- Selecting assessment participants from the assessment entity
- Establishing assessment outputs (e.g., ratings and/or including project-specific findings)
- Establishing assessment constraints (e.g., time spent on site)

In addition to these major tailoring options, the CMMI assessment method description details a number of specific tailoring options driven by considering the objectives of a particular assessment and the business goals of the organization and/or project. Documentation of CMMI assessment plans and results must always include a description of the tailoring options selected, as well as any model tailoring. Such documentation will enable a determination to be made of the comparability of assessment results across organizations.

PART 2

Assessment Requirements for CMMI (ARC) v 0.2

The Assessment Requirements for CMMI (ARC) v0.2 is the basis for a "full-up" comprehensive assessment method that has been named SCAMPI (Standard CMMI Assessment Method for Process Improvement). In addition, the community would benefit from having available several types of assessment methods, which address differing needs while at the same time having some degree of commonality. A particular assessment class would be defined by identifying the ARC requirements that a member of the class would need to satisfy. For example, SCAMPI would satisfy the entire set of requirements; other classes would satisfy a subset of the ARC requirements. Only the comprehensive SCAMPI would provide the basis for ratings for benchmarking, as described in Part 1. The SEI, as custodian of the CMMI Product Suite, will assure that any public comments or statements about maturity levels or ratings resulting from a SCAMPI meet the criteria stated below to assure quality and consistency. Examples of classes of assessments are attached as an addendum to this document.

At this time it appears that the following are the key differentiating attributes for assessment classes: (1) the degree of confidence in the assessment outcomes, (2) whether ratings should be produced, and if so, what type, and (3) assessment cost. In future discussions, the ARC requirements will be evaluated along these and possibly additional dimensions to provide further utility for organizations considering their assessment needs.

Requirements for Assessment Phases:

A1. The method shall provide the required activities for the three assessment phases:

- plan and prepare for Assessment.
- conduct assessment.

- report results.

A2. The method shall be documented and, at a minimum, shall include:

- version of the CMMI model, including discipline and representation, that is to be used as a reference model,
- version and assessment class of the ARC upon which the assessment method is based, and
- description of the activities, artifacts, and guidance that implement each of the assessment activities.

Requirements for Planning and Preparing for the Assessment:

A3. The method shall provide for obtaining the sponsor's approval and commitment to proceed with the assessment process prior to the initiation of the "conduct assessment" phase.

A4. The method shall provide for the preparation of the members of the assessed organization who will participate in the assessment.

A5. The method shall provide for the development of an assessment plan that, at a minimum, identifies:

- CMMI model scope, including any tailoring.
- organizational scope.
- assessment objectives and their alignment with the organizational unit's business objectives.
- assessment context which includes: a) the size of the organizational unit to be assessed, b) the demographics of the organizational unit, c) the application discipline of the products or services, d) the size, criticality, and complexity of the products or services, and e) the quality characteristics of the products or services.
- schedule for the activities.
- people who will conduct the assessment, including the sponsor, the assessment team leader, the assessment team members, any organizational support staff, etc. and their defined responsibilities, resources, and budget required to perform the activities.
- form and content of assessment results, the ownership thereof, the anticipated use of the results, and any restrictions upon their use.

- mechanisms to be used to ensure the confidentiality of assessment data and associated sources.
- anticipated follow-on activities.
- planned tailoring of the assessment method and associated trade-offs, including the sample size or coverage of the organizational unit.
- risks associated with assessment execution.
- provision for approving and documenting any changes to the assessment plan.

A6. The method shall require the sponsor and the assessment team leader to approve the contents of the assessment plan prior to the initiation of the "conduct assessment" phase.

Requirements for Conducting the Assessment:

A7. The method shall collect data by administering instruments, e.g., questionnaires, surveys.

A8. The method shall collect data by conducting interviews, e.g., project leaders, managers.

A9. The method shall collect data by reviewing documentation, e.g., organizational policies, project procedures, implementation-level work products.

A10. The method shall require consensus of all assessment team members in decisions when determining the validity of observations, creating findings, and establishing ratings.

A11. The method shall require a mechanism for consolidating the data collected during an assessment into accurate observations according to the following criteria:

- The observation was derived from objective evidence seen or heard during data collection sessions.

- The observation is worded appropriately, e.g., clear, phrased without attribution, expressed in site terminology.
- The observation is relevant to the reference model and can be associated with a specific model component.

A12. The method shall require a mechanism for validating each accurate observation as:

- corroborated by data obtained from at least: a) two multiple, independent sources (e.g., a document and an interview session, or two different interview sessions), and b) interviews of people performing the related work or review of implementation-level work products, and
- consistent with other validated observations.

A13. The method shall require at a minimum, related documentation to support the implementation of each of the specific and generic goals within the scope of the assessment.

A14. The method shall require a mechanism for determining that sufficient data has been collected to cover the scope of the assessment, according to the following minimum set of rules:

- A specific or generic goal has sufficient data coverage if sufficient validated observations exist for each practice related to the goal, including acceptable alternative practices, so that the assessment team can judge the extent of the goal's satisfaction relative to: a) the reference model, b) the organizational unit, and c) the organizational unit's life cycle(s).
- In a staged representation, a process area has sufficient data coverage if all of its specific and generic goals are adequately covered.
- In a continuous representation, a process area has sufficient data coverage if all of its specific and generic goals within the assessment scope are adequately covered up through the capability level being investigated for each process area.

A15. The method shall require a mechanism for consolidating observations into draft findings of strengths and weaknesses relative to the reference model.

A16. The method shall require that the assessment participants be presented with the draft findings in order to solicit their responses for verification of the findings' accuracy, clarity, and understandability.

A17. The method shall define the prerequisites for a rating process within a staged representation, which specify that:

- An assessment team can rate a specific or generic goal when valid observations related to the goal meet the method's defined data coverage criteria.
- An assessment team can rate a process area when it has rated each of the specific and generic goals.
- An assessment team can determine a maturity level rating once it has rated all of the process areas within that level and each level below.

A18. The method shall define the prerequisites for a rating process within a continuous representation, which specify that:

- An assessment team can rate a specific or generic goal when valid observations related to the goal meet the method's defined data coverage criteria.
- An assessment team can determine the capability level of a process area when it has rated each of the generic goals at or below that certain level and rated all of the specific goals considering all of the specific practices of the process area up to that certain level.
- An assessment team can determine a maturity level rating by comparing the achieved capability level profile of the process areas to the equivalent staging when provided.

A19. The method shall require that maturity level ratings and capability level ratings are based on the rating scales used in the specified reference model.

A20. The method shall require a mechanism for rating, provided the prerequisites of rating have been completed, of the following categories of model components within the assessment scope, based on the rating scales in the specified model:

- specific and generic goals
- process areas (staged representation)
- capability level for the process areas (continuous representation)

A21. The method shall require assessment teams to base ratings on their validated observations.

A22. The method shall rate each specific and generic goal in accordance with the following rules:

- Rate the goal "satisfied" if the associated findings indicate that, in the judgment of the assessment team, there are no significant weaknesses.
- Rate the goal "unsatisfied" if the associated findings indicate that, in the judgment of the assessment team, there are significant weaknesses in the appraised entity's satisfaction of this goal.
- Determine the capability level rating for the specific goals in the continuous representation.
- Determine the capability level when (a) all of the generic goals at or below that certain level have been rated, and (b) all of the specific goals considering all of the specific practices of the process area up to that certain level.

A23. The method shall rate each process area within the assessment scope in accordance with the following rules:

- For a staged representation, the process area is "satisfied" if and only if all of its specific and generic goals are rated "satisfied."
- For a continuous representation, the process area is given a capability level rating based upon the highest level at which its process area specific and generic goals have been satisfied.
- When a process area is determined to be not applicable to the organizational unit's environment, the process area is designated as "not applicable" and is not rated.
- When a process area is outside of the assessment scope or if the associated findings do not meet the method's defined criteria for data coverage, the process area is designated as "not rated" and is not rated.

A24. The method shall rate maturity level, when desired by the assessment sponsor, in accordance with the following rules:

- A maturity level for a staged representation is achieved if all process areas within that level and within each lower level are satisfied or not applicable.
- A maturity level for a continuous representation is achieved if the process area profile is at or above the target profile for that maturity level in the equivalent staging.

Requirements for Reporting Results:

A25. The method shall require for reporting the assessment results to the assessment sponsor.

A26. The method shall define a mechanism for translating assessment observations into associated process attribute outcomes in accordance with ISO/IEC TR 15504-2 clause 7.6.

A27. At a minimum, the assessment record shall include:

- date of assessment
- assessment plan
- identification of objective evidence gathered
- assessment method used along with any tailoring options
- set of process area profiles resulting from the assessment, including the process areas included in the assessment scope, each process area's rating (satisfied or unsatisfied), and identification of process areas that were determined to be "not applicable" and those that were not rated.
- findings including strengths and weaknesses
- ratings
- risks associated with the accuracy and completeness of assessment outputs.
- identification of any additional data collected to support process improvement.

A28. The method shall report assessment results to the CMMI custodian, or its designee, for the purpose of reporting aggregated assessment information to the constituent community for benchmarking.

Guidance for Assessment Implementation:

A29. The method documentation shall require guidance for:

- identifying an assessment's purpose, objectives, and constraints.
- determining the suitability of the assessment method relative to the assessment's purpose, objectives and constraints.

A30. The method documentation shall require guidance for identifying the scope of the CMMI model to be used as a reference model for the assessment. The assessment model scope shall include identification of:

- CMMI model, its version, its discipline (e.g., systems engineering or software engineering), and representation (e.g., staged or continuous)
- process areas to be investigated,
- capability levels to be investigated for each process area (continuous representation), and
- maturity levels to be investigated (staged representation).

A31. The method documentation shall require guidance for identifying the scope of the organizational unit to be assessed. The organizational scope will include identification of:

- the sponsor of the assessment and the sponsor's relationship to the organizational unit being assessed,
- projects within the organizational unit that have committed to participate, and
- names and organizational unit or subunits of participants who will be interviewed.

A32. The method documentation shall require guidance for selecting assessment team members and criteria for qualification including:

- discipline-specific experience
- management experience
- experience or formal training in the reference model
- formal training in the assessment method for each team member.

A33. The method documentation shall require guidance for an assessment team leader's qualification criteria including:

- authorization in good standing in the SEI Appraiser Program that provides training to qualified persons, authorizes the use of CMMI assessment material, and monitors the use of such material.
- training and experience using the reference model
- training and experience using the assessment method, and
- experience in delivering training, managing teams, facilitating group discussions, and making presentations.

A34. The method documentation shall require guidance for determining the appropriate size of the assessment team.

A35. The method documentation shall require guidance on the roles and responsibilities of assessment team members.

A36. The method documentation shall require guidance for the responsibilities of the sponsor of the assessment to include:

- verify that the assessment team leader and assessment team members have the necessary competence and skills,
- ensure that the appropriate organizational units or subunits participate in the assessment,
- understand the importance of ensuring confidentiality for the assessment participants and assessment outcomes, and
- ensure that resources are made available to conduct the assessment.

A37. The method documentation shall require guidance for the assessment team leader to:

- confirm the sponsor's commitment to proceed with the assessment,
- ensure that participants in the assessment are briefed on the purpose, scope, and approach of the assessment,
- ensure that he/she has adequate training and knowledge to interpret the reference model,
- ensure that all members of the assessment team have appropriate prerequisite knowledge and skills,
- ensure that all members of the assessment team have formal training or equivalent experience in the use of the reference model
- deliver assessment team training to ensure that the assessment team members have the necessary knowledge and skills to perform the method, the necessary competence to use instruments or tools chosen to support the assessment, and access to documented guidance on how to perform the defined assessment activities,
- return assessment results to the appropriate assessment data repository, and
- verify and document that the assessment method requirements have been met.

A38. The method documentation shall require guidance for determining the assessment resources that will be required, including the amount of time required to conduct an assessment.

A39. The method documentation shall require guidance for assessment logistics.

A40. The method documentation shall require guidance for collecting data on the organizational unit's process areas specified in the assessment scope and associating the data to the specific and generic practices of the reference model.

A41. The method documentation shall require guidance for creation of final findings, both strengths and weaknesses relative to the reference model.

A42. The method documentation shall require guidance for compilation of the assessment record, e.g. assessment final report, for retention by the sponsor that will support understanding of the output of the assessment.

A43. The method documentation shall require guidance for protecting the confidentiality of assessment data and non-attribution of data contributed by assessment participants.

A44. The method documentation shall require guidance for recording and maintaining data that supports the assessment team's findings and rating decisions, for recording traceability between the data collected during the assessment and the assessment results, and for retention and safekeeping of assessment records.

Characteristics of CMMI Assessment Classes

Characteristics	Class A	Class B	Class C
Examples	Full Comprehensive (e.g., SCAMPI)	Initial (first-time) Incremental (partial) Self-assessment	Quick-look
Benefits (advantages)	Thorough model coverage; strengths and weaknesses for each PA investigated; robustness of method with consistent, repeatable results; provides objective view	Organization gains insight into own capability; provides a starting point or focuses on areas that need most attention; promotes buy-in; less comprehensive, thus less expensive than having a Class A assessment.	Not used for process improvement. Quick check looking for risk areas in development process; inexpensive; little training is needed
Disadvantages	Demands significant resources	Does not necessarily provide completeness and cannot be used for level rating	Not enough depth to base action plan modifications
Sponsor	Senior manager of organization	Any manager sponsoring a SPI program	Any internal manager
Team composition	External & Internal; for evaluations, external	Internal	External or internal
Team size	4-10 persons + Lead Assessor	1-6 + leader	1-2 + leader
Team qualifications	Experienced	Moderate experience	Moderate + Novices
Team leader requirements	Lead Assessor	Lead Assessor or Person experienced in method	Person trained in method
Estimate of effort expended:			
Team hours	80-120 hours	40-80 hours	10-20 hours
Interview hours	15 hours	8-10 hours	Optional

Examples of Assessment Class Requirements

ARC v0.2 - Requirements	Class A	Class B	Class C
A1 – Assessment Phases	yes	yes	optional
A2 – Documentation of method	yes	yes	yes
A3 – Sponsor's approval	yes	yes	yes
A4 – Preparation of participants	yes	yes	yes
A5 – Assessment plan	yes	yes	yes
A6 – Approval of plan	yes	yes	yes
A7 – Data from questionnaires	yes	optional	optional
A8 – Data from interviews	yes	optional	optional
A9 – Data from documents	yes	optional	optional
A10 – Consensus of team members	yes	yes	optional
A11 – Accurate observations	yes	yes	yes
A12 – Validation of observations (corroboration)	yes	yes	optional
A13 – Required documentation	yes	optional	optional
A14 – Sufficiency of data	yes	optional	optional
A15 – Draft findings preparation	yes	optional	optional
A16 – Draft findings presentations	yes	optional	optional
A17 – Prerequisites for rating (staged representation)	yes	Not applicable	Not applicable
A18 – Prerequisites for rating (continuous representation)	yes	Not applicable	Not applicable
A19 – Rating scales	yes	Not applicable	Not applicable
A20 – Components for rating	yes	Not applicable	Not applicable
A21 – Basis for rating	yes	Not applicable	Not applicable
A22 – Rating of goals	yes	no	no
A23 - Rating of process areas	yes	no	no
A24 – Rating of maturity level	yes	no	no
A25 – Report results to sponsor	yes	yes	optional

ARC v0.2 - Requirements	Class A	Class B	Class C
A26 – Translation for 15504	optional	no	no
A27 – Assessment record	yes	yes	optional
A28 – Assessment results to CMMI Custodian	yes	optional	no
A29 – Guidance for identifying purpose of assessment	yes	yes	yes
A30 – Guidance for CMMI model scope	yes	yes	yes
A31 – Guidance for organizational scope	yes	yes	yes
A32 – Guidance for team member selection	yes	yes	yes
A33 – Guidance for team leader selection	yes	yes	yes
A34 – Guidance for size of team	yes	yes	yes
A35 – Guidance for roles of team members	yes	yes	yes
A36 – Guidance for responsibilities of sponsor	yes	yes	yes
A37 – Guidance for team leader	yes	yes	yes
A38 – Guidance for determining assessment resources, schedule, etc.	yes	yes	yes
A39 – Guidance for logistics	yes	yes	yes
A40 – Guidance for mapping data to reference model	yes	yes	yes
A41 – Guidance for creation of final findings	yes	Optional	Optional
A42 – Guidance for final report	yes	no	no
A43 – Guidance for protecting confidentiality of data	yes	yes	yes
A44 – Guidance for maintaining data	yes	yes	yes

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