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Capability Maturity Model® Integration (CMMI℠), Version 1.1

CMMI℠ for Systems Engineering, Software Engineering, and Integrated Product and Process Development (CMMI-SE/SW/IPPD, V1.1)

Staged Representation

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Improving processes for better products

CMMI Product Team

December 2001

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In Memory of

Carolyn Marie Tady

our dedicated team member and friend

April 27, 1958 - November 27, 2001

Preface

The Capability Maturity Model® Integration (CMMI℠) project has involved a large number of people from different organizations throughout the world. These organizations were using a CMM® or multiple CMMs and were interested in the benefits of developing an integration framework to aid in enterprise-wide process improvement. [FM101.T101]

The CMMI project work is sponsored by the U.S. Department of Defense (DoD), specifically the Office of the Under Secretary of Defense, Acquisition, Technology, and Logistics (OUSD/AT&L). Industry sponsorship is provided by the Systems Engineering Committee of the National Defense Industrial Association (NDIA). [FM101.T102]

Organizations from industry, government, and the Software Engineering Institute (SEI) joined together to develop the CMMI Framework, a set of integrated CMMI models, a CMMI appraisal method, and supporting products. These organizations donated the time of one or more of their people to participate in the CMMI project. [FM101.T103]

Development History

The CMMI project team has been working to provide guidance that encourages process improvement in organizations of any structure. [FM101.HDA101.T101]

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 management and development, and Integrated Product and Process Development. [FM101.HDA101.T102]

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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, have limited these organizations' ability to focus their improvements successfully. Further, applying multiple models that are not integrated within and across an organization becomes more costly in terms of training, appraisals, and improvement activities. A set of integrated models that successfully addresses multiple disciplines and has integrated training and appraisal support solves these problems. [FM101.HDA101.T103]

The CMM Integration[SM] project was formed to sort out the problem of using multiple CMMs. The CMMI Product Team's mission was to combine three source models—(1) Capability Maturity Model for Software (SW-CMM) v2.0 draft C, (2) Electronic Industries Alliance Interim Standard (EIA/IS) 731, and (3) Integrated Product Development Capability Maturity Model (IPD-CMM) v0.98—into a single improvement framework for use by organizations pursuing enterprise-wide process improvement. [FM101.HDA101.T106]

Developing a set of integrated models has involved more than simply adding existing model materials together. Using processes that promote consensus, the CMMI Product Team has built a framework that accommodates multiple disciplines and is flexible enough to support two different representations (staged and continuous). [FM101.HDA101.T107]

Using information from popular and well-regarded models as source material, the CMMI Product Team created a cohesive set of integrated models that can be adopted by those currently using other CMMs, as well as by those new to the CMM concept. [FM101.HDA101.T108]

During the development phase of the CMMI project, the team's mission included the development of a common framework for supporting the future integration of other discipline-specific CMMI models. Furthermore, the team's mission included the objective of ensuring that all of the products developed are consistent and compatible with the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) 15504 Technical Report for Software Process Assessment. [FM101.HDA101.T109]

[SM] CMM Integration is a service mark of Carnegie Mellon University.

CMMI version 0.2 was publicly reviewed and used in initial pilot activities. Following release of that version, improvement was guided by change requests from the public review, piloting organizations, and various focus group sessions. The CMMI Product Team evaluated more than 3,000 change requests to create CMMI version 1.0. Shortly thereafter, version 1.02 was released, which incorporated several minor improvements. As with any release, however, the opportunity for further improvement remained. Version 1.1 accommodates further improvements from early use as well as more than 1,500 change requests. [FM101.HDA101.T111]

Acknowledgments

Many talented people were involved as part of the product team for the CMMI Product Suite[1]. Four primary groups involved in this development have been the Steering Group, Product Team, Configuration Control Board, and Stakeholders/Reviewers. [FM101.HDA102.T101]

The Steering Group guides and approves the plans of the Product Team, provides consultation on significant CMMI project issues, and ensures involvement from a variety of interested communities. [FM101.HDA102.T102]

The Product Team writes, reviews, revises, discusses, and agrees on the structure and technical content of the CMMI Product Suite, including the framework, models, training, and appraisal materials. Development activities were based on an A-Specification provided by the Steering Group, the three source models, and comments from Stakeholders and Steering Group members. [FM101.HDA102.T104]

The Configuration Control Board has been the official mechanism for controlling changes to the CMMI models. As such, this group ensures integrity over the life of the product suite by reviewing all changes made to the baseline and approving only those changes that meet the criteria for the upcoming release. [FM101.HDA102.T113]

The Stakeholder/Reviewer group of organizations provided valuable insight into the early effort that was used to combine the models. Their review of multiple versions of the product suite gave the Product Team valuable perspectives. [FM101.HDA102.T105]

Both present and emeritus members of the four groups involved in developing CMMI products are listed in Appendix E. [FM101.HDA102.T111]

[1] See Chapter 3 for a discussion of both "CMMI Product Suite" and "CMMI Framework," which clarifies the difference between these two.

Where to Look for Additional Information

You can find additional information, such as the intended audience, background, history of the CMMI models, and the benefits of using the CMMI models, in various other sources. Many of these sources are documented on the CMMI Web site, which is located at http://www.sei.cmu.edu/cmmi/. [FM101.HDA103.T101]

Feedback Information

Suggestions for improving the CMMI Product Suite are welcome. See the CMMI Web site for information on how to provide feedback: http://www.sei.cmu.edu/cmmi/. [FM101.HDA104.T101]

If you have questions, send an email to cmmi-comments@sei.cmu.edu. [FM101.HDA104.T103]

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1 Introduction

A model is a simplified representation of the world. Capability Maturity Models (CMMs) contain the essential elements of effective processes for one or more bodies of knowledge. These elements are based on the concepts developed by Crosby, Deming, Juran, and Humphrey [Crosby 79, Juran 88, Deming 86, Humphrey 89]. [FM108.T101]

Like other CMMs, Capability Maturity Model Integration (CMMI) models provide guidance to use when developing processes. CMMI models are not processes or process descriptions. The actual processes used in an organization depend on many factors, including application domain(s) and organization structure and size. In particular, the process areas of a CMMI model typically do not map one to one with the processes used in your organization. [FM108.T102]

About CMMI Models

A process is a leverage point for an organization's sustained improvement. The purpose of CMM Integration is to provide guidance for improving your organization's processes and your ability to manage the development, acquisition, and maintenance of products or services. CMM Integration places proven approaches into a structure that helps your organization appraise its organizational maturity or process area capability, establish priorities for improvement, and implement these improvements. [FM108.HDA102.T101]

The CMMI Product Suite contains and is produced from a framework that provides the ability to generate multiple models and associated training and appraisal materials. These models may reflect content from bodies of knowledge (e.g., systems engineering, software engineering, Integrated Product and Process Development) in combinations most useful to you (e.g., CMMI-SE/SW, CMMI-SE/SW/IPPD). [FM108.HDA102.T103]

Your organization can use a CMMI model to help set process-improvement objectives and priorities, improve processes, and provide guidance for ensuring stable, capable, and mature processes. A selected CMMI model can serve as a guide for improvement of organizational processes. [FM108.HDA102.T102]

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

[FM108.HDA102.T104]

Selecting a CMMI Model

There are multiple CMMI models available, as generated from the CMMI Framework. Consequently, you need to be prepared to decide which CMMI model best fits your organization's process-improvement needs. [FM108.HDA101.T101]

You must select a representation, either continuous or staged, and you must determine the bodies of knowledge you want to include in the model your organization will use. [FM108.HDA101.T102]

Representations: Continuous or Staged?

There are many valid reasons to select one representation or the other. Perhaps your organization will choose to use the representation it is most familiar with. The following lists describe some of the possible advantages and disadvantages to selecting each of the two representations. [FM108.HDA101.HDB101.T101]

Continuous Representation

If you choose the continuous representation for your organization, expect that the model will do the following: [FM108.HDA101.HDB102.T101]

- Allow you to select the order of improvement that best meets the organization's business objectives and mitigates the organization's areas of risk
- Enable comparisons across and among organizations on a process area by process area basis or by comparing results through the use of equivalent staging
- Provide an easy migration from Electronic Industries Alliance Interim Standard (EIA/IS) 731 to CMMI
- Afford an easy comparison of process improvement to International Organization for Standardization and International Electrotechnical Commission (ISO/IEC) 15504, because the organization of process areas is similar to ISO/IEC 15504

Staged Representation

If you choose the staged representation for your organization, expect that the model will do the following: [FM108.HDA101.HDB103.T101]

- Provide a proven sequence of improvements, beginning with basic management practices and progressing through a predefined and proven path of successive levels, each serving as a foundation for the next
- Permit comparisons across and among organizations by the use of maturity levels
- Provide an easy migration from the SW-CMM to CMMI
- Provide a single rating that summarizes appraisal results and allows comparisons among organizations

Whether used for process improvement or appraisals, both representations are designed to offer essentially equivalent results. [FM108.HDA101.HDB103.T102]

Which Integrated Model to Choose?

Currently there are three bodies of knowledge available to you when selecting a CMMI model: [FM108.HDA101.HDB104.T106]

- systems engineering
- software engineering
- Integrated Product and Process Development

This text will refer to these bodies of knowledge as "disciplines." For example, when we refer to selecting a "discipline," it can be one of the choices listed above. The CMMI Product Team envisions that other bodies of knowledge will be integrated into the CMMI Framework. [FM108.HDA101.HDB104.T107]

Disciplines: What is Different?

Depending on the discipline you select for your CMMI model, read the relevant sections below. [FM108.HDA101.HDB109.T101]

Systems Engineering

Systems engineering covers the development of total systems, which may or may not include software. Systems engineers focus on transforming customer needs, expectations, and constraints into product solutions and supporting these product solutions throughout the life of the product. [FM108.HDA101.HDB105.T101]

When you select systems engineering for your model, the model will contain the Process Management, Project Management, Support, and Engineering process areas. Discipline amplifications specific to systems engineering are provided to help you interpret specific practices for systems engineering where necessary. (See Chapter 2 for more information about discipline amplifications.) [FM108.HDA101.HDB105.T102]

Software Engineering

Software engineering covers the development of software systems. Software engineers focus on applying systematic, disciplined, and quantifiable approaches to the development, operation, and maintenance of software. [FM108.HDA101.HDB106.T101]

When you select software engineering for your model, the model will contain the Process Management, Project Management, Support, and Engineering process areas. Discipline amplifications specific to software engineering are provided to help you interpret specific practices for software engineering. [FM108.HDA101.HDB106.T102]

Integrated Product and Process Development

Integrated Product and Process Development (IPPD) is a systematic approach that achieves a timely collaboration of relevant stakeholders throughout the life of the product to better satisfy customer needs, expectations, and requirements. The processes to support an IPPD approach are integrated with the other processes in the organization. The IPPD process areas, specific goals, and specific practices alone cannot achieve IPPD. If a project or organization chooses IPPD, it performs the IPPD-specific practices concurrently with other specific practices used to produce products (e.g., the Engineering process areas). That is, if an organization or project wishes to use IPPD, it chooses a model with one or more disciplines in addition to selecting IPPD. [FM108.HDA101.HDB107.T101]

When you select IPPD for your model, the model will contain the Process Management, Project Management, Support, and Engineering process areas that apply to both IPPD and the other discipline(s) you have selected for your model. Discipline amplifications specific to IPPD are also provided to help you interpret specific practices for IPPD. [FM108.HDA101.HDB107.T102]

A Recommendation

The CMMI Product Team recommends that you select both systems and software engineering if you are selecting either of these disciplines. This recommendation is based on the fact that the only distinction between the models for each of these disciplines is the type of discipline amplifications included. Otherwise, these models are exactly the same. [FM108.HDA101.HDB110.T101]

The Content of CMMI Models

CMMI models with a staged representation consist of seven chapters and five appendices: [FM108.HDA103.T101]

- Chapter 1: The Introduction chapter (this chapter) offers a broad view of CMMI models, suggestions on where to look for other information not included in CMMI models, and the typographical conventions used throughout CMMI models.
- Chapter 2: The Model Components chapter describes model components, including maturity levels, goals, and practices.
- Chapter 3: The Model Terminology chapter describes the approach taken to using terms in CMMI models, as well as how terms were selected for and defined in the glossary.
- Chapter 4: The Common Features, Generic Goals, and Generic Practices chapter describes the common features and generic practices, which ensure that the implementation of processes associated with process areas is effective, repeatable, and lasting.
- Chapter 5: The Framework Interactions chapter provides insight into the meaning of basic and advanced processes for Project Management, Process Management, Support, and Engineering process areas.
- Chapter 6: The Using CMMI Models chapter explains the ways in which your organization can use CMMI models.
- Chapter 7: The Process Areas chapter contains descriptions of the required, expected, and informative components of the model you have selected, including goals, practices, subpractices, and typical work products.

The Appendices are as follows: [FM108.HDA103.T104]

- Appendix A: The References appendix contains information you can use to locate the documented sources, such as reports, process-improvement models, industry standards, and books, that were used to create the content of the CMMI models.
- Appendix B: The Acronyms appendix defines acronyms used in the CMMI models.
- Appendix C: The Glossary appendix defines terms used in the CMMI models that are not adequately defined in context or by the Webster's American English dictionary.
- Appendix D: The Required and Expected Model Elements appendix contains the required and expected components of each of the process areas. No informative material is given other than the process area purpose, titles, and component titles.

- Appendix E: The CMMI Project Participants appendix contains a list of participants on the CMMI Steering Group, Product Team, Configuration Control Board, and Stakeholder/Reviewer Team.

Typographical Conventions

The typographical conventions used in CMMI models optimize their readability and usability. We present model components in formats that allow you to quickly find them on the page. The following sections provide some tips for locating various model components in CMMI models. [FM108.HDA105.T101]

See Chapter 2 for definitions of the model components mentioned. [FM108.HDA105.T102]

Specific and Generic Goals

All specific and generic goal titles and statements appear in bold. The goal number (for example, SG 1 for specific goal 1 or GG 2 for generic goal 2) appears to the left of the goal title. (Refer to the Numbering Scheme section below.) The goal statement appears in bold italics below the goal title in a gray box. A goal title is an abbreviated form of the goal statement and is used for reference purposes. Goal titles are not used for appraisals or rated in any way. Only goal statements are designed to be used for process-improvement and appraisal purposes. [FM108.HDA105.HDB101.T101]

Specific and Generic Practices

All specific and generic practice titles and statements appear in bold and are indented from the left margin. The practice number appears to the left of the practice title. (Refer to the Numbering Scheme section below.) The practice statements appear in bold italics within a gray box below the practice title. The practice title is not used for appraisals or rated in any way. The practice statement is designed to be used for process-improvement and appraisal purposes. [FM108.HDA105.HDB102.T101]

References

All references to model components are identifiable in CMMI models because they always appear in italics and always begin with the phrase *"Refer to."* [FM108.HDA105.HDB103.T101]

Introductory Notes, Typical Work Products, and Subpractices

These headings indicate the location of introductory notes, typical work products, and subpractices within a process area. [FM108.HDA105.HDB104.T101]

Examples

Throughout the process areas, all examples appear in boxes and are formatted in a narrower and smaller font than most other model elements. [FM108.HDA105.HDB109.T101]

Generic Practice Elaborations

After the specific practices, the generic practice titles and statements appear that apply to the process area. After each generic practice statement, an elaboration may appear in plain text with the heading "Elaboration." The elaboration provides information about how the generic practice should be interpreted for the process area. If there is no elaboration present, the application of the generic practice is obvious without an elaboration. [FM108.HDA105.HDB105.T101]

Discipline Amplifications

Model components that provide guidance for interpreting model information for specific disciplines (e.g., IPPD, systems engineering, or software engineering) are called "discipline amplifications." Discipline amplifications are added to other model components where necessary. These are easy to locate because they appear on the right side of the page and have a title indicating the discipline that they address (for example, "For Software Engineering"). [FM108.HDA105.HDB106.T101]

Numbering Scheme

In the staged representation, the specific and generic goals are numbered sequentially. Each specific goal has a number beginning with SG (SG 1, for example). Each generic goal has a number beginning with GG (GG 2, for example). [FM108.HDA105.HDB107.T111]

Specific practices begin with SP, followed by a number in the form x.y. The x is the number of the specific goal that the practice is mapped to, and the y is the practice's sequence number. For example, in the Requirements Management process area, the first specific practice associated with specific goal 1 is numbered SP 1.1, and the second is SP 1.2. [FM108.HDA105.HDB107.T112]

Generic practices are numbered in a similar way beginning with GP, followed by a number in the form x.y, where x is the number of the generic goal that the practice is mapped to, and y is the practice's sequence number. A second number is used for the generic practices, indicating the sequence number of the practice within one of the four common feature categories to which it belongs. For example, the first generic practice associated with GG 2 is numbered GP 2.1 and CO 1. The CO 1 number indicates that the generic practice is the first generic practice organized under the Commitment to Perform common feature. [FM108.HDA105.HDB107.T113]

See Chapter 2 for more information about common features.

[FM108.HDA105.HDB107.T114]

Paragraph Identifier Codes

At the end of single paragraphs or sets of paragraphs throughout the model, you will find unique strings of characters in brackets (e.g., [FM108.HDA105.HDB107.T110]). These strings of characters are called "paragraph identifier codes." These codes are unique, but do not necessarily appear in any numeric sequence. These codes do not hold any special meaning for model users, but rather, they enable the generation of individual CMMI models from the CMMI Framework database and allow you to accurately identify specific text in the model.

[FM108.HDA105.HDB108.T101]

2 Model Components

You have chosen the staged representation. The components of both the staged and continuous representations are process areas, specific goals, specific practices, generic goals, generic practices, typical work products, subpractices, notes, discipline amplifications, generic practice elaborations, and references. [FM103.T102]

The staged representation organizes process areas into five maturity levels to support and guide process improvement. The staged representation groups process areas by maturity level, indicating which process areas to implement to achieve each maturity level. Maturity levels (described later in this chapter) represent a process-improvement path illustrating improvement evolution for the entire organization pursuing process improvement. [FM103.T104]

Within each process area, the specific goals and specific practices are listed first, followed by the generic goals and generic practices. The staged representation uses four common features to organize the generic practices. [FM103.T106]

In this chapter, we describe each component of the staged representation, the relationships between the components, and the relationships between the two representations. Many of the components described here are also components of CMMI models with a continuous representation. [FM103.T108]

Structural Overview

A CMMI model with a staged representation is illustrated in Figure 1.

[FM103.HDA101.T102]

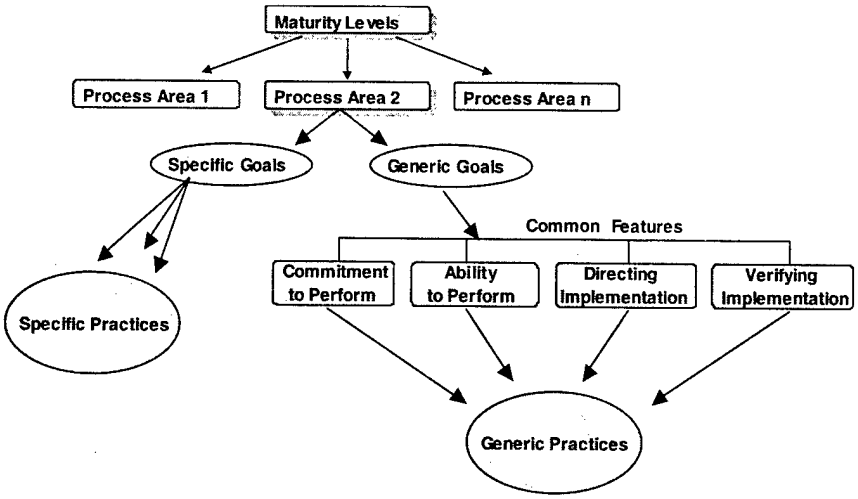


Figure 1: CMMI Model Components [FM103.HDA101.T104]

CMMI models are designed to describe discrete levels of process improvement. In the staged representation, maturity levels provide a recommended order for approaching process improvement in stages. As illustrated in Figure 1, maturity levels organize the process areas. Within the process areas are generic and specific goals as well as generic and specific practices. Common features organize generic practices. [FM103.HDA101.T109]

This representation focuses on best practices your organization can use to improve processes in the process areas that are within the maturity level it chooses to achieve. Before you begin using a CMMI model for improving processes, you must map your processes to CMMI process areas. This mapping enables you to control process improvement in your organization by helping you track your organization's level of conformance to the CMMI model you are using. It is not intended that every CMMI process area maps one to one with your organization's processes. [FM103.HDA101.T110]

Maturity Levels

The maturity level of an organization provides a way to predict the future performance of an organization within a given discipline or set of disciplines. Experience has shown that organizations do their best when they focus their process-improvement efforts on a manageable number of process areas that require increasingly sophisticated effort as the organization improves. [FM103.HDA101.HDB101.T101]

A maturity level is a defined evolutionary plateau of process improvement. Each maturity level stabilizes an important part of the organization's processes. [FM103.HDA101.HDB101.T102]

In CMMI models with a staged representation, there are five maturity levels, each a layer in the foundation for ongoing process improvement, designated by the numbers 1 through 5: [FM103.HDA101.HDB101.T103]

1. Initial
2. Managed
3. Defined
4. Quantitatively Managed
5. Optimizing

Maturity Level Details

Maturity levels consist of a predefined set of process areas. The maturity levels are measured by the achievement of the specific and generic goals that apply to each predefined set of process areas. The following sections describe the characteristics of each maturity level in detail. [FM103.HDA101.HDB103.T101]

Maturity Level 1: Initial

At maturity level 1, processes are usually ad hoc and chaotic. The organization usually does not provide a stable environment. Success in these organizations depends on the competence and heroics of the people in the organization and not on the use of proven processes. In spite of this ad hoc, chaotic environment, maturity level 1 organizations often produce products and services that work; however, they frequently exceed the budget and schedule of their projects.
[FM103.HDA101.HDB104.T101]

Maturity level 1 organizations are characterized by a tendency to over commit, abandon processes in the time of crisis, and not be able to repeat their past successes. [FM103.HDA101.HDB104.T102]

Maturity Level 2: Managed

At maturity level 2, an organization has achieved all the specific and generic goals of the maturity level 2 process areas. In other words, the projects of the organization have ensured that requirements are managed and that processes are planned, performed, measured, and controlled. [FM103.HDA101.HDB105.T101]

The process discipline reflected by maturity level 2 helps to ensure that existing practices are retained during times of stress. When these practices are in place, projects are performed and managed according to their documented plans. [FM103.HDA101.HDB105.T102]

At maturity level 2, requirements, processes, work products, and services are managed. The status of the work products and the delivery of services are visible to management at defined points (for example, at major milestones and at the completion of major tasks). [FM103.HDA101.HDB105.T103]

Commitments are established among relevant stakeholders and are revised as needed. Work products are reviewed with stakeholders and are controlled. The work products and services satisfy their specified requirements, standards, and objectives. [FM103.HDA101.HDB105.T104]

Maturity Level 3: Defined

At maturity level 3, an organization has achieved all the specific and generic goals of the process areas assigned to maturity levels 2 and 3. At maturity level 3, processes are well characterized and understood, and are described in standards, procedures, tools, and methods. [FM103.HDA101.HDB106.T101]

The organization's set of standard processes, which is the basis for maturity level 3, is established and improved over time. These standard processes are used to establish consistency across the organization. Projects establish their defined processes by tailoring the organization's set of standard processes according to tailoring guidelines. [FM103.HDA101.HDB106.T102]

The organization's management establishes process objectives based on the organization's set of standard processes and ensures that these objectives are appropriately addressed. [FM103.HDA101.HDB106.T103]

A critical distinction between maturity level 2 and maturity level 3 is the scope of standards, process descriptions, and procedures. At maturity level 2, the standards, process descriptions, and procedures may be quite different in each specific instance of the process (for example, on a particular project). At maturity level 3, the standards, process descriptions, and procedures for a project are tailored from the organization's set of standard processes to suit a particular project or organizational unit. The organization's set of standard processes includes the processes addressed at maturity level 2 and maturity level 3. As a result, the processes that are performed across the organization are consistent except for the differences allowed by the tailoring guidelines. [FM103.HDA101.HDB106.T104]

Another critical distinction is that at maturity level 3, processes are typically described in more detail and more rigorously than at maturity level 2. At maturity level 3, processes are managed more proactively using an understanding of the interrelationships of the process activities and detailed measures of the process, its work products, and its services. [FM103.HDA101.HDB106.T105]

Maturity Level 4: Quantitatively Managed

At maturity level 4, an organization has achieved all the specific goals of the process areas assigned to maturity levels 2, 3, and 4 and the generic goals assigned to maturity levels 2 and 3. Subprocesses are selected that significantly contribute to overall process performance. These selected subprocesses are controlled using statistical and other quantitative techniques. [FM103.HDA101.HDB107.T101]

Quantitative objectives for quality and process performance are established and used as criteria in managing processes. Quantitative objectives are based on the needs of the customer, end users, organization, and process implementers. Quality and process performance are understood in statistical terms and are managed throughout the life of the processes. [FM103.HDA101.HDB107.T102]

For these processes, detailed measures of process performance are collected and statistically analyzed. Special causes of process variation[2] are identified and, where appropriate, the sources of special causes are corrected to prevent future occurrences. [FM103.HDA101.HDB107.T103]

Quality and process performance measures are incorporated into the organization's measurement repository to support fact-based decision making in the future. [FM103.HDA101.HDB107.T105]

A critical distinction between maturity level 3 and maturity level 4 is the predictability of process performance. At maturity level 4, the performance of processes is controlled using statistical and other quantitative techniques, and is quantitatively predictable. At maturity level 3, processes are only qualitatively predictable. [FM103.HDA101.HDB107.T106]

Maturity Level 5: Optimizing

At maturity level 5, an organization has achieved all the specific goals of the process areas assigned to maturity levels 2, 3, 4, and 5 and the generic goals assigned to maturity levels 2 and 3. Processes are continually improved based on a quantitative understanding of the common causes of variation[3] inherent in processes. [FM103.HDA101.HDB108.T101]

Maturity level 5 focuses on continually improving process performance through both incremental and innovative technological improvements. Quantitative process-improvement objectives for the organization are established, continually revised to reflect changing business objectives, and used as criteria in managing process improvement. The effects of deployed process improvements are measured and evaluated against the quantitative process-improvement objectives. Both the defined processes and the organization's set of standard processes are targets of measurable improvement activities. [FM103.HDA101.HDB108.T103]

[2] See the definition of "special cause of process variation" in Appendix C, the glossary.
[3] See the definition of "common cause of process variation" in Appendix C, the glossary.

Process improvements to address common causes of process variation and measurably improve the organization's processes are identified, evaluated, and deployed. 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 performance of the organization's processes is continually improved. [FM103.HDA101.HDB108.T104]

Optimizing processes that are agile and innovative depends on the participation of an empowered workforce aligned with the business values and objectives of the organization. The organization's ability to rapidly respond to changes and opportunities is enhanced by finding ways to accelerate and share learning. Improvement of the processes is inherently part of everybody's role, resulting in a cycle of continual improvement. [FM103.HDA101.HDB108.T105]

A critical distinction between maturity level 4 and maturity level 5 is the type of process variation addressed. At maturity level 4, processes are concerned with addressing special causes of process variation and providing statistical predictability of the results. Though processes may produce predictable results, the results may be insufficient to achieve the established objectives. At maturity level 5, processes are concerned with addressing common causes of process variation and changing the process (that is, shifting the mean of the process performance) to improve process performance (while maintaining statistical predictability) to achieve the established quantitative process-improvement objectives. [FM103.HDA101.HDB108.T106]

Advancing Through Maturity Levels

Organizations can achieve progressive improvements in their organizational maturity by first achieving stability at the project level and continuing to the most advanced-level, organization-wide continuous process improvement, using both quantitative and qualitative data to make decisions. [FM103.HDA101.HDB109.T101]

Since organizational maturity describes the range of expected results that can be achieved by an organization, it is one means of predicting the most likely outcomes from the next project the organization undertakes. For instance, at maturity level 2, the organization has been elevated from ad hoc to disciplined by establishing sound project management. As your organization achieves the generic and specific goals for the set of process areas in a maturity level, you are increasing your organizational maturity and reaping the benefits of process improvement. [FM103.HDA101.HDB109.T102]

Skipping Maturity Levels

The staged representation identifies the maturity levels through which an organization should evolve to establish a culture of excellence. Because each maturity level forms a necessary foundation on which to build the next level, trying to skip maturity levels is usually counterproductive. [FM103.HDA101.HDB110.T101]

At the same time, you must recognize that process-improvement efforts should focus on the needs of the organization in the context of its business environment and that process areas at higher maturity levels may address the current needs of an organization or project. For example, organizations seeking to move from maturity level 1 to maturity level 2 are frequently told to establish a process group, which is addressed by the Organizational Process Focus process area that resides at maturity level 3. While a process group is not a necessary characteristic of a maturity level 2 organization, it can be a useful part of the organization's approach to achieving maturity level 2.
[FM103.HDA101.HDB110.T102]

This situation is sometimes characterized as "establishing a maturity level 1 engineering process group to bootstrap the maturity level 1 organization to maturity level 2." Maturity level 1 process-improvement activities may depend primarily on the insight and competence of the engineering process group staff until an infrastructure to support more disciplined and widespread improvement is in place. [FM103.HDA101.HDB110.T103]

Organizations can institute specific process improvements at any time they choose, even before they are prepared to advance to the maturity level at which the specific practice is recommended. However, organizations should understand that the stability of these improvements is at a greater risk, since the foundation for their successful institutionalization has not been completed. Processes without the proper foundation may fail at the very point they are needed most: under stress. [FM103.HDA101.HDB110.T104]

A defined process that is characteristic of a maturity level 3 organization can be placed at great risk if maturity level 2 management practices are deficient. For example, management may make a poorly planned schedule commitment or fail to control changes to baselined requirements. Similarly, many organizations collect the detailed data characteristic of maturity level 4, only to find the data uninterpretable because of inconsistency in processes and measurement definitions.
[FM103.HDA101.HDB110.T105]

Another example of using processes associated with higher maturity level process areas is in the process of building products. Certainly, we would expect maturity level 1 organizations to perform requirements analysis, design, integration, and verification. However, these activities are not described until maturity level 3, where they are described as the coherent, well-integrated engineering processes of a project management capability, put in place so that the engineering improvements are not lost by having an ad-hoc management process. [FM103.HDA101.HDB110.T106]

Required, Expected, and Informative Components

The components of a CMMI model are grouped into three categories that reflect how they are to be interpreted: [FM103.HDA101.HDB111.T101]

- Required: Specific goals and generic goals are required model components. These components must be achieved by an organization's planned and implemented processes. Required components are essential to rating the achievement of a process area. Goal achievement (or satisfaction) is used in appraisals as the basis upon which process area satisfaction and organizational maturity are determined. Only the statement of the specific or generic goal is a required model component. The title of a specific or generic goal and any notes associated with the goal are considered informative model components.
- Expected: Specific practices and generic practices are expected model components. Expected components describe what an organization will typically implement to achieve a required component. Expected components guide those implementing improvements or performing appraisals. Either the practices as described, or acceptable alternatives to them, are expected to be present in the planned and implemented processes of the organization before goals can be considered satisfied. Only the statement of the practice is an expected model component. The title of a practice and any notes associated with the practice are considered informative model components.
- Informative: Subpractices, typical work products, discipline amplifications, generic practice elaborations, goal and practice titles, goal and practice notes, and references are informative model components that help model users understand the goals and practices and how they can be achieved. Informative components provide details that help model users get started in thinking about how to approach goals and practices.

The CMMI glossary of terms is not a required, expected, or informative element of CMMI models. The terms in the glossary should be interpreted within the context of the component where they appear. [FM103.HDA101.HDB111.T102]

When you use a CMMI model as a guide, you plan and implement 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 (or processes) that addresses either the specific and generic practices of the process area or alternatives that clearly and unequivocally accomplish a result that meets the goal associated with that specific or generic practice. [FM103.HDA101.HDB111.T103]

Model Components

Process Areas

A process area is a cluster of related practices in an area that, when performed collectively, satisfy a set of goals considered important for making significant improvement in that area. All CMMI process areas are common to both continuous and staged representations. In the staged representation, process areas are organized by maturity levels. [FM103.HDA102.HDB101.T101]

Specific Goals

Specific goals apply to a process area and address the unique characteristics that describe what must be implemented to satisfy the process area. Specific goals are required model components and are used in appraisals to help determine whether a process area is satisfied. [FM103.HDA102.HDB103.T101]

Specific Practices

A specific practice is an activity that is considered important in achieving the associated specific goal. The specific practices describe the activities expected to result in achievement of the specific goals of a process area. Specific practices are expected model components. [FM103.HDA102.HDB104.T101]

Common Features

Four common features organize the generic practices of each process area. Common features are model components that are not rated in any way. They are only groupings that provide a way to present the generic practices. Each common feature is designated by an abbreviation as shown: [FM103.HDA102.HDB106.T101]

- Commitment to Perform (CO)
- Ability to Perform (AB)
- Directing Implementation (DI)

- Verifying Implementation (VE)

See Chapter 4 for a more detailed description of the common features. [FM103.HDA102.HDB106.T102]

Typical Work Products

Typical work products are an informative model component that provides example outputs from a specific or generic practice. These examples are called "typical work products" because there are often other work products that are just as effective, but are not listed. [FM103.HDA102.HDB113.T101]

Subpractices

Subpractices are detailed descriptions that provide guidance for interpreting specific or generic practices. Subpractices may be worded as if prescriptive, but are actually an informative component in CMMI models meant only to provide ideas that may be useful for process improvement. [FM103.HDA102.HDB114.T101]

Discipline Amplifications

Discipline amplifications are informative model components that contain information relevant to a particular discipline and are associated with specific practices. For example, if in the CMMI-SE/SW model, you want to find a discipline amplification for software engineering, you would look in the model for items labeled "For Software Engineering." The same is true for other disciplines. [FM103.HDA102.HDB115.T101]

Generic Goals

Generic goals are called "generic" because the same goal statement appears in multiple process areas. In the staged representation, each process area has only one generic goal. Achievement of a generic goal in a process area signifies improved control in planning and implementing the processes associated with that process area, thus indicating whether these processes are likely to be effective, repeatable, and lasting. Generic goals are required model components and are used in appraisals to determine whether a process area is satisfied. (Only the generic goal title and statement appear in the process areas.) [FM103.HDA102.HDB105.T101]

See Chapter 4 for a detailed description of the generic goals. [FM103.HDA102.HDB105.T102]

Generic Practices

Generic practices provide institutionalization to ensure that the processes associated with the process area will be effective, repeatable, and lasting. Generic practices are categorized by generic goals and common features and are expected components in CMMI models. (Only the generic practice title, statement, and elaborations appear in the process areas.) [FM103.HDA102.HDB107.T101]

Generic Practice Elaborations

Generic practice elaborations are informative model components that appear in each process area to provide guidance on how the generic practices should uniquely be applied to 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 are described. [FM103.HDA102.HDB116.T101]

References

References are informative model components that direct the user to additional or more detailed information in related process areas. Typical phrases expressing these pointers are *"Refer to the Organizational Training process area for more information about identifying training needs and providing the necessary training"* or *"Refer to the Decision Analysis and Resolution process area for more information about evaluating and selecting among alternatives."* All references are clearly marked in italics. [FM103.HDA102.HDB117.T102]

Model Representation Comparison

The continuous representation uses capability levels to measure process improvement, while the staged representation uses maturity levels. The main difference between maturity levels and capability levels is the representation they belong to and how they are applied: [FM103.HDA103.T101]

- Capability levels, which belong to the continuous representation, apply to an organization's process-improvement achievement for each process area. There are six capability levels, numbered 0 through 5. Each capability level corresponds to a generic goal and a set of generic and specific practices.

Capability Level	Continuous Representation Capability Levels
0	Incomplete
1	Performed

2	Managed
3	Defined
4	Quantitatively Managed
5	Optimizing

[FM103.HDA103.T102]

- Maturity levels, which belong to the staged representation, apply to an organization's overall maturity. There are five maturity levels, numbered 1 through 5. Each maturity level comprises a predefined set of process areas.

Maturity Level	Staged Representation Maturity Levels
1	Initial
2	Managed
3	Defined
4	Quantitatively Managed
5	Optimizing

[FM103.HDA103.T104]

The continuous representation has more specific practices than the staged representation because the continuous representation has two types of specific practices, base and advanced, whereas the staged representation has only one type of specific practice. [FM103.HDA103.T105]

In the continuous representation, generic practices exist for capability levels 1-5, whereas, in the staged representation, only the generic practices from capability levels 2 and 3 appear; there are no generic practices from capability levels 1, 4, and 5. [FM103.HDA103.T106]

There is an additional appendix, Appendix F, in the continuous representation that discusses equivalent staging. Equivalent staging enables the results of appraisals using the continuous representation to be translated into maturity levels. [FM103.HDA103.T107]

3 Model Terminology

In any CMMI model, the terminology used and how it is defined are important to understanding the content. Although a model glossary is included in Appendix C, some terms are used in a special way throughout CMMI models. [FM114.T101]

Terminology Evolution

When developing the CMMI models, the Product Team started with the terminology used in the source models. However, since this terminology was not consistent, and in some instances terms conflicted with one another, the Product Team had to decide which terms should be used and which were to be abandoned. This was accomplished throughout the model development process by consensus. [FM114.HDA101.T101]

Inevitably, consensus was reached when the terms selected were neutral, broad, and flexible. When conflicts were identified among potential user groups (government and industry) or discipline areas (software engineering, systems engineering, and Integrated Product and Process Development [IPPD]), a compromise was reached. The team chose not to use some terms that were too closely identified with a specific interest group and instead favored terms that were more broadly accepted. [FM114.HDA101.T102]

Furthermore, terms were chosen to express concepts consistently throughout the models. Definitions for these terms were communicated to the entire Product Team to encourage consistent usage. Despite these efforts, some differences in interpretation are inevitable. You should always apply the guidance herein in the way that provides the greatest value to your process-improvement effort. [FM114.HDA101.T103]

Common Terminology with Special Meaning

Some of the terms used in CMMI models have meanings attached to them that differ from their everyday use. These terms are not included in the glossary; we have explained their use in CMMI models in this chapter. [FM114.HDA102.T101]

Adequate, Appropriate, As Needed

These words are used so that you can interpret goals and practices in light of your organization's business objectives. When using any CMMI model, you must interpret the practices so that they work for your organization. These terms are used in goals and practices where certain activities may not be done all of the time. [FM114.HDA102.HDB101.T101]

Establish and Maintain

When using a CMMI model, you will encounter goals and practices that include the phrase "establish and maintain." This phrase connotes a meaning beyond the component terms; it includes documentation and usage. For example, "Establish and maintain an organizational policy for planning and performing the organizational process focus process" means that not only must a policy be formulated, but it also must be documented and it must be used throughout the organization. [FM114.HDA102.HDB102.T101]

Customer

A "customer" is the party (individual, project, or organization) responsible for accepting the product or for authorizing payment. The customer is external to the project, but not necessarily external to the organization. The customer may be a higher level project. Customers are a subset of stakeholders. [FM114.HDA102.HDB103.T101]

Stakeholder

A "stakeholder" is a group or individual that is affected by or in some way accountable for the outcome of an undertaking. Stakeholders may include project members, suppliers, customers, end users, and others. [FM114.HDA102.HDB104.T101]

Relevant Stakeholder

The term "relevant stakeholder" is used to designate a stakeholder that is identified for involvement in specified activities and is included in an appropriate plan. (See the Plan Stakeholder Involvement specific practice in the Project Planning process area and the Identify and Involve Relevant Stakeholders generic practice.) [FM114.HDA102.HDB105.T101]

Manager

Within the scope of CMMI models, the word "manager" refers to a person who provides technical and administrative direction and control to those 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. [FM114.HDA102.HDB106.T101]

Project Manager

In the CMMI Product Suite, a "project manager" is the person responsible for planning, directing, controlling, structuring, and motivating the project. The project manager is responsible for satisfying the customer. [FM114.HDA102.HDB107.T101]

Senior Manager

The term "senior manager," when used in a CMMI model, refers to a management role at a high enough level in an organization that the primary focus of the person filling the role is the long-term vitality of the organization, rather than short-term project and contractual concerns and pressures. A senior manager has authority to direct the allocation or reallocation of resources in support of organizational process-improvement effectiveness. [FM114.HDA102.HDB108.T101]

A senior manager can be any manager who satisfies this description, including the head of the organization. Synonyms for "senior manager" include "executive" and "top-level manager." However, these synonyms are not used in CMMI models to ensure consistency and usability.
[FM114.HDA102.HDB108.T102]

Shared Vision

In the CMMI Product Suite, a "shared vision" is a common understanding of guiding principles including mission, objectives, expected behavior, values, and final outcomes, which are developed and used by a group, such as an organization, project, or team. Creating a shared vision requires that all people in the group have an opportunity to speak and be heard about what really matters to them.
[FM114.HDA102.HDB109.T101]

Organization

An organization is typically an administrative structure in which people collectively manage one or more projects as a whole, and whose projects share a senior manager and operate under the same policies. However, the word "organization" as used throughout CMMI models can apply to one person who performs a function in a small organization that might be performed by a group of people in a large organization. See the definition of "organizational unit" in Appendix C, the glossary.
[FM114.HDA102.HDB110.T101]

Enterprise

When CMMI models refer to an "enterprise," they illustrate the larger entity not always reached by the word "organization." Companies may consist of many organizations in many different locations with different customers. The word "enterprise" refers to the full composition of companies. [FM114.HDA102.HDB111.T101]

Development

The word "development," when used in the CMMI Product Suite, implies not only development activities, but also maintenance activities. Projects that benefit from the best practices of CMMI can focus on maintenance, development, or both. [FM114.HDA102.HDB112.T101]

Discipline

The word "discipline," when used in the CMMI Product Suite, refers to the bodies of knowledge available to you when selecting a CMMI model (e.g., systems engineering). The CMMI Product Team envisions that other bodies of knowledge will be integrated into the CMMI Framework. [FM114.HDA102.HDB113.T101]

Project

In CMMI models, a "project" is 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. A project can be composed of projects. [FM114.HDA102.HDB114.T101]

Product

The word "product" is used throughout the CMMI Product Suite to mean any tangible output or service that is a result of a process and that is intended for delivery to a customer or end user. A product is a work product that is delivered to the customer. [FM114.HDA102.HDB115.T101]

Work Product

The term "work product" is used throughout the CMMI Product Suite to mean any artifact produced by a process. These artifacts can include files, documents, parts of the product, services, processes, specifications, and invoices. Examples of processes to be considered as work products include a manufacturing process, a training process, and a disposal process for the product. A key distinction between a work product and a product component is that a work product need not be engineered or part of the end product. [FM114.HDA102.HDB116.T101]

In various places in CMMI models, you will see the phrase "work products and services." Even though the definition of work product includes services, this phrase is used to emphasize the inclusion of services in the discussion. [FM114.HDA102.HDB116.T102]

Product Component

The term "product component" is used as a relative term in CMMI models. In CMMI, product components are lower level components of the product; product components are integrated to "build" the product. There may be multiple levels of product components. A product component is any work product that must be engineered (requirements defined and designs developed and implemented) to achieve the intended use of the product throughout its life. [FM114.HDA102.HDB117.T101]

Product components are parts of the product delivered to the customer and may serve in the manufacture or use of the product. A car engine and a piston are examples of product components of a car (the product). The manufacturing process to machine the piston, if delivered to the customer, is a product component. However, if the manufacturing process is used to machine the piston delivered to the customer, the manufacturing process is a work product, not a product component. The repair process used to remove the engine from the car for repair and the process used to train the mechanic to repair the engine are typically examples of product components because they are delivered to the customer. [FM114.HDA102.HDB117.T102]

Appraisal

In the CMMI Product Suite, an "appraisal" is an examination of one or more processes by a trained team of professionals using an appraisal reference model as the basis for determining strengths and weaknesses. [FM114.HDA102.HDB118.T101]

Assessment

In the CMMI Product Suite, an "assessment" is an appraisal that an organization does to and for itself for the purposes of process improvement. The word "assessment" is also used in the CMMI Product Suite in an everyday English sense (e.g., risk assessment).

[FM114.HDA102.HDB119.T101]

Tailoring Guidelines

Tailoring a process makes, alters, or adapts the process description for a particular end. For example, a project establishes its defined process by tailoring from the organization's set of standard processes to meet the objectives, constraints, and environment of the project.

[FM114.HDA102.HDB120.T101]

"Tailoring guidelines" are used in CMMI models to enable organizations to implement standard processes appropriately in their projects. The organization's set of standard processes is described at a general level that may not be directly usable to perform a process. [FM114.HDA102.HDB120.T102]

Tailoring guidelines aid those who establish the defined processes for projects. Tailoring guidelines cover (1) selecting a standard process, (2) selecting an approved life-cycle model, and (3) tailoring the selected standard process and life-cycle model to fit project needs. Tailoring guidelines describe what can and cannot be modified and identify process components that are candidates for modification.
[FM114.HDA102.HDB120.T103]

Verification

Although "verification" and "validation" at first seem quite similar in CMMI models, on closer inspection you can see that each addresses different issues. Verification confirms that work products properly reflect the requirements specified for them. In other words, verification ensures that "you built it right." [FM114.HDA102.HDB121.T101]

Validation

Validation confirms that the product, as provided, will fulfill its intended use. In other words, validation ensures that "you built the right thing."
[FM114.HDA102.HDB122.T101]

Goal

A "goal" is a required CMMI component that can be either a generic goal or a specific goal. When you see the word "goal" in a CMMI model, it always refers to model components (for example, generic goal, specific goal). (In Chapter 2, see the definitions of "specific goal" and "generic goal" and descriptions of how these terms are used in the CMMI Product Suite.) [FM114.HDA102.HDB123.T101]

Objective

When used as a noun in the CMMI Product Suite, the term "objective" replaces the word "goal" as used in its common everyday sense, since the word "goal" is reserved for use when referring to the CMMI model components called "specific goals" and "generic goals."
[FM114.HDA102.HDB124.T101]

Quality and Process-Performance Objectives

The phrase "quality and process-performance objectives" covers objectives and requirements for product quality, service quality, and process performance. Process performance objectives include product quality; however, to emphasize the importance of product quality, the phrase "quality and process-performance objectives" is used in the CMMI Product Suite rather than just "process performance objectives." [FM114.HDA102.HDB125.T101]

Standard

When you see the word "standard" used as a noun in a CMMI model, it refers to the formal mandatory requirements developed and used to prescribe consistent approaches to development (for example, ISO standards, IEEE standards, organizational standards). Instead of using "standard" in its common everyday sense, we chose another term that means the same thing (for example, typical, traditional, usual, customary). [FM114.HDA102.HDB126.T101]

CMMI-Specific Terminology

The following terms were created for CMMI products or are critical to the understanding of CMMI products. [FM114.HDA103.T101]

CMMI Product Suite

The "CMMI Product Suite" is the complete set of products developed around the CMMI concept. These products include the framework itself, models, appraisal methods, appraisal materials, and various types of training that are produced from the CMMI Framework. [FM114.HDA103.HDB101.T101]

CMMI Framework

The "CMMI Framework" is the basic structure that organizes CMMI components, including common elements of the current CMMI models as well as rules and methods for generating models, their appraisal methods (including associated artifacts), and their training materials. The framework enables new disciplines to be added to CMMI so that the new disciplines will integrate with the existing ones. [FM114.HDA103.HDB102.T101]

CMMI Model

Since the CMMI Framework can generate different models based on the needs of the organization using it, there are multiple CMMI models. Consequently, the phrase "CMMI model" could be any one of many collections of information. The phrase "CMMI models" refers to one, some, or the entire collection of possible models that can be generated from the CMMI Framework. [FM114.HDA103.HDB103.T101]

Peer Review

The term "peer review" is used in the CMMI Product Suite instead of the term "work product inspection." Essentially, these terms mean the same thing. A peer review is the review of work products performed by peers during development of the work products to identify defects for removal. [FM114.HDA103.HDB104.T101]

Organization's Set of Standard Processes

An "organization's set of standard processes" contains the definitions of the processes that guide all activities 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 implemented in projects across the organization. A standard process enables consistent development and maintenance activities across the organization and is essential for long-term stability and improvement. [FM114.HDA103.HDB105.T101]

The organization's set of standard processes describes the fundamental process elements that will be part of the projects' defined processes. It also describes the relationships (for example, ordering and interfaces) between these process elements. [FM114.HDA103.HDB105.T102]

Process

A "process," as used in the CMMI Product Suite, consists of activities that can be recognized as implementations of practices in a CMMI model. These activities can be mapped to one or more practices in CMMI process areas to allow a model to be useful for process improvement and process appraisal. (In Chapter 2, see the definition of "process area" and a description of how this term is used in the CMMI Product Suite.) [FM114.HDA103.HDB106.T101]

Managed Process

A "managed process" is a performed process that is planned and executed in accordance with policy; employs skilled people having adequate resources to produce controlled outputs; involves relevant stakeholders; is monitored, controlled, and reviewed; and is evaluated for adherence to its process description. [FM114.HDA103.HDB107.T101]

Defined Process

A "defined process" is a managed process that is tailored from the organization's set of standard processes according to the organization's tailoring guidelines; has a maintained process description; and contributes work products, measures, and other process-improvement information to the organizational process assets. (In Chapters 2 and 4, see the descriptions of how "defined process" is used in the CMMI Product Suite.) [FM114.HDA103.HDB108.T101]

A project's defined process provides a basis for planning, performing, and improving the project's tasks and activities. A project may have more than one defined process (for example, one for developing the product and another for testing the product). [FM114.HDA103.HDB108.T102]

Organizational Process Assets

"Organizational process assets" are artifacts that relate to describing, implementing, and improving processes (e.g., policies, measurements, process descriptions, and process implementation support tools). The term "process assets" is used to indicate that these artifacts are developed or acquired to meet the business objectives of the organization, and they represent investments by the organization that are expected to provide current and future business value.
[FM114.HDA103.HDB109.T101]

The organizational process assets that are described in CMMI models include the following: [FM114.HDA103.HDB109.T102]

- Organization's set of standard processes, including the process architectures and process elements
- Descriptions of life-cycle models approved for use
- Guidelines and criteria for tailoring the organization's set of standard processes
- Organization's measurement repository
- Organization's process asset library

In addition, some process areas mention two additional organizational process assets: the organization's process performance baselines and the organization's process performance models. [FM114.HDA103.HDB109.T103]

Process Architectures

"Process architecture" describes the ordering, interfaces, interdependencies, and other relationships among the process elements in a standard process. Process architecture also describes the interfaces, interdependencies, and other relationships between process elements and external processes (for example, contract management). [FM114.HDA103.HDB110.T101]

Product Life Cycle

A "product life cycle" is the period of time, consisting of phases, 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 description of a product life cycle may not be adequate. Therefore, the organization may define a set of approved product life-cycle models. These models are typically found in published literature and are likely to be tailored for use in an organization. [FM114.HDA103.HDB111.T101]

A product life cycle could consist of the following phases: (1) concept/vision, (2) feasibility, (3) design/development, (4) production, and (5) phase out. [FM114.HDA103.HDB111.T102]

Organization's Measurement Repository

The "organization's measurement repository" is a repository 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 analyze the measurement data. [FM114.HDA103.HDB112.T101]

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 costs; peer review efficiency and coverage statistics; and the number and severity of defects. [FM114.HDA103.HDB112.T102]

Organization's Process Asset Library

The "organization's process asset library" is a library of information used to store and make available process assets that are potentially useful to those who are defining, implementing, and managing processes in the organization. This library contains process assets such as documents, document fragments, process implementation aids, and other artifacts. [FM114.HDA103.HDB113.T101]

Examples of process-related documentation include policies, defined processes, checklists, lessons-learned documents, templates, standards, procedures, plans, and training materials. This library is an important resource that can help reduce the effort in using processes. [FM114.HDA103.HDB113.T102]

Document

A "document" is a collection of data, regardless of the medium on which it is recorded, that generally has permanence and can be read by humans or machines. So, documents include both paper and electronic documents. [FM114.HDA103.HDB114.T101]

4 Common Features, Generic Goals, and Generic Practices

Overview

This chapter discusses generic goals, generic practices, common features, and institutionalization. Since you have chosen the staged representation, this chapter provides the generic practices organized by common feature. Common features are model components that are unique to the staged representation. [FM122.HDA101.T101]

The generic goals and practices enable the organization to institutionalize best practices. Therefore, the discussion of institutionalization can also serve as a summary of the generic goals and practices. [FM122.HDA101.T102]

The organization can achieve progressive improvements in its maturity by first achieving stability at the project level and continuing to the most advanced-level, organization-wide continuous process improvement using both quantitative and qualitative data to make decisions. [FM122.HDA101.T103]

Characteristics of Institutionalization

Institutionalization is a critical aspect of process improvement and is an important concept within each maturity level. When mentioned below in the maturity level descriptions, institutionalization implies that the process is ingrained in the way the work is performed. [FM122.HDA102.T101]

A managed process is institutionalized by doing the following: [FM122.HDA102.T102]

- Adhering to organizational policies
- Following established plans and process descriptions
- Providing adequate resources (including funding, people, and tools)
- Assigning responsibility and authority for performing the process

- Training the people performing and supporting the process
- Placing designated work products under appropriate levels of configuration management
- Identifying and involving relevant stakeholders
- Monitoring and controlling the performance of the process against the plans for performing the process and taking corrective actions
- Objectively evaluating the process, its work products, and its services for adherence to the process descriptions, objectives, and standards, and addressing noncompliance
- Reviewing the activities, status, and results of the process with higher level management, and taking corrective action

A defined process is institutionalized by doing the following: [FM122.HDA102.T103]

- Addressing the items that institutionalize a managed process
- Establishing the description of the defined process for the project or organizational unit
- Collecting work products, measures, and improvement information derived from planning and performing the defined process

A quantitatively managed process is institutionalized by doing the following: [FM122.HDA102.T104]

- Addressing the items that institutionalize a defined process
- Controlling the process using statistical and other quantitative techniques such that product quality, service quality, and process performance attributes are measurable and controlled throughout the project

An optimizing process is institutionalized by doing the following: [FM122.HDA102.T105]

- Addressing the items that institutionalize a quantitatively managed process
- Improving the process based on an understanding of the common causes of variation inherent in the process such that the process focuses on continually improving the range of process performance through both incremental and innovative improvements

Generic Goals

In the staged representation, each process area has only one generic goal. A generic goal describes what institutionalization must be achieved to satisfy a process area. The generic goal that a process area contains depends on what maturity level the process area belongs to. Each process area at maturity level 2 contains the following generic goal: [FM122.HDA105.T101]

GG 2 Institutionalize a Managed Process

The process is institutionalized as a managed process.

Each process area at maturity level 3 or higher contains the following generic goal: [FM122.HDA105.T102]

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process.

The numbering given to these generic goals (and also to the generic practices) reflects the particular capability level they are associated with in the continuous representation. The same numbering is used in the staged representation to maintain traceability between the two representations. [FM122.HDA105.T103]

When a process is institutionalized as a defined process, the items essential to a managed process are also addressed. Thus, GG 3 implies GG 2. In process areas at maturity level 3 and higher, only GG 3 appears. However, the generic practices that appear under GG 2 also appear under GG 3 as well as the generic practices unique to GG 3. All of these generic practices appear under GG 3 grouped by the common features. [FM122.HDA105.T104]

The organization's set of standard processes should collectively cover all processes needed by the organization and projects, including those processes addressed at maturity level 2. Therefore, GG 3 is not required for maturity level 2, but is required for maturity level 3 and above. For example, when you achieve maturity level 3, you must apply GG 3 to the maturity level 2 process areas. [FM122.HDA105.T105]

Common Features

Common features are predefined attributes that group generic practices into categories. Common features are model components that are not rated in any way. They are only groupings that provide a way to present the generic practices. [FM122.HDA103.T101]

There are four common features used in CMMI models with a staged representation: Commitment to Perform, Ability to Perform, Directing Implementation, and Verifying Implementation. [FM122.HDA103.T102]

Commitment to Perform (CO) groups the generic practices related to creating policies and securing sponsorship. [FM122.HDA103.T104]

Ability to Perform (AB) groups the generic practices related to ensuring that the project and/or organization has the resources it needs. [FM122.HDA103.T105]

Directing Implementation (DI) groups the generic practices related to managing the performance of the process, managing the integrity of its work products, and involving relevant stakeholders. [FM122.HDA103.T106]

Verifying Implementation (VE) groups the generic practices related to review by higher level management and objective evaluation of conformance to process descriptions, procedures, and standards. [FM122.HDA103.T107]

In the following section, generic practices are listed by their common feature categories. This section also contains subpractices and other informative model components that clarify the generic practice statements found in the process areas. These details of the generic practices do not appear in the process areas. [FM122.HDA103.T103]

Generic Practices Listed by Common Feature

Generic practices appear at the end of each process area, follow the generic goal, and are grouped by the common features. Generic practice elaborations may appear after generic practices to show how the generic practices should uniquely be applied to the process area. [FM122.HDA104.T101]

Although this information is applied throughout the CMMI models in multiple process areas, the entire text of each generic practice is not repeated in every process area (e.g., subpractices and work products are omitted). Instead, only the generic practice titles and statements appear in each process area. As you apply generic practices within each process area, refer to this section for the details of these generic practices. [FM122.HDA104.T102]

Within the common feature categories below, you will find generic practices with different numbering. Some begin with GP 2 and others begin with GP 3. The generic practices that begin with GP 2 apply to process areas at maturity levels 2 through 5. The generic practices that begin with GP 3 also apply to process areas at maturity levels 2 through 5. However they are not expected to be performed until after the organization has reached maturity level 2 and is addressing maturity level 3 or higher. [FM122.HDA104.T104]

Only the generic practices that apply to the staged representation appear in this chapter. There are other generic practices that are used by the continuous representation. These generic practices are associated with capability levels 1, 4, and 5, and are found in chapter 4 of the continuous representation. [FM122.HDA104.T103]

Commitment to Perform

GP 2.1 Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the process.

The purpose of this generic practice is to define the organizational expectations for the process and make these expectations visible to those in the organization who are affected. In general, senior management is responsible for establishing and communicating guiding principles, direction, and expectations for the organization. [GP103]

Not all direction from senior management will bear the label "policy." The existence of appropriate organizational direction is the expectation of this generic practice, regardless of what it is called or how it is imparted. [GP103.N101]

Ability to Perform

GP 2.2 Plan the Process

Establish and maintain the plan for performing the process.

The purpose of this generic practice is to determine what is needed to perform the process and achieve the established objectives, to prepare a plan for performing the process, to prepare a process description, and to get agreement on the plan from relevant stakeholders. [GP104]

Requirements for the process's specified work products and for performing the work may be derived from other requirements. In the case of a project's processes, they may come from that project's requirements management process; in the case of an organization's process, they may come from organizational sources. [GP104.N101]

The objectives for the process may be derived from other plans (e.g., the project plans). Included are objectives for the 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. [GP104.N102]

Although a generic practice, by definition, applies to all process areas, the practical implications of applying a generic practice vary for each process area. Consider two examples that illustrate these differences as they relate to planning the process. First, the planning described by this generic practice as applied to the Project Monitoring and Control process area may be carried out in full by the processes associated with the Project Planning process area. In such a situation, the generic practice imposes no additional expectations for planning. Second, the planning described by this generic practice as applied to the Project Planning process area typically would not be addressed by the processes associated with other process areas in the model. Therefore, the generic practice sets an expectation that the project planning process itself be planned. It is important to be aware of the extent to which this generic practice may either reinforce expectations set elsewhere in the model, or set new expectations that should be addressed. [GP104.N105]

Establishing a plan includes documenting the plan and providing a process description. Maintaining the plan includes changing it as necessary, in response to either corrective actions or to changes in requirements and objectives for the process. [GP104.N103]

The plan for performing the process typically includes the following: [GP104.N106]

- Process description
- Standards for the work products and services of 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)
- 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
- Work products 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
- Involvement of identified stakeholders
- Activities for monitoring and controlling the process
- Objective evaluation activities for the process and the work products
- Management review activities for the process and the work products

Subpractices

1. Obtain management sponsorship for performing the process. [GP104.SubP101]

2. Define and document the process description. [GP104.SubP102]

   The process description, which includes relevant standards and procedures, may be included as part of the plan for performing the process or may be included in the plan by reference. [GP104.SubP102.N101]

3. Define and document the plan for performing the process. [GP104.SubP103]

   This plan may be a stand-alone document, embedded in a more comprehensive document, or distributed across multiple documents. In the case of the plan being distributed across multiple documents, ensure that a coherent picture is preserved of who does what. Documents may be hardcopy or softcopy. [GP104.SubP103.N102]

4. Review the plan with relevant stakeholders and get their agreement. [GP104.SubP104]

   This includes reviewing that the planned process satisfies the applicable policies, plans, requirements, and standards to provide assurance to relevant stakeholders. [GP104.SubP104.N101]

5. Revise the plan as necessary. [GP104.SubP105]

GP 2.3 Provide Resources

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

The purpose of this generic practice is to ensure that the resources necessary 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. [GP105]

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. [GP105.N101]

GP 2.4 Assign Responsibility

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

The purpose of this generic practice is to ensure that there is accountability throughout the life of the process for performing the process and achieving the specified results. The people assigned must have the appropriate authority to perform the assigned responsibilities. [GP106]

Responsibility can be assigned using detailed job descriptions or in living documents, such as the plan for performing the process. Dynamic assignment of responsibility is another legitimate way to perform this generic practice, as long as the assignment and acceptance of responsibility are ensured throughout the life of the process. [GP106.N101]

Subpractices

1. Assign overall responsibility and authority for performing the process. [GP106.SubP101]
2. Assign responsibility for performing the specific tasks of the process. [GP106.SubP102]
3. Confirm that the people assigned to the responsibilities and authorities understand and accept them. [GP106.SubP103]

GP 2.5 Train People

Train the people performing or supporting the process as needed.

The purpose of this generic practice is to ensure that the people have the necessary skills and expertise to perform or support the process. [GP107]

Appropriate training is provided to the people who will be performing the work. Overview training is provided to orient people who interact with those performing the work. [GP107.N101]

Examples of methods for providing training include: self study; self-directed training; self-paced, programmed instruction; formalized on-the-job training; mentoring; and formal and classroom training. [GP107.N104]

Training supports the successful performance of the process by establishing a common understanding of the process and by imparting the skills and knowledge needed to perform the process. [GP107.N103]

GP 3.1 Establish a Defined Process

Establish and maintain the description of a defined process.

The purpose of this generic practice is to establish and maintain a description of the process that is tailored from the organization's set of standard processes to address the needs of a specific instantiation. The organization should have standard processes that cover the process area, as well as have guidelines for tailoring these standard processes to meet the needs of a project or organizational function. 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. [GP114]

Refer to the Organizational Process Definition process area for more information about the organization's set of standard processes and tailoring guidelines. [GP114.R101]

The descriptions of the defined processes provide the basis for planning, performing, and managing the activities, work products, and services associated with the process. [GP114.N102]

Subpractices

1. Select from the organization's set of standard processes those processes that cover the process area and best meet the needs of the project or organizational function. [GP114.SubP101]
2. Establish the defined process by tailoring the selected processes according to the organization's tailoring guidelines. [GP114.SubP102]
3. Ensure that the organization's process objectives are appropriately addressed in the defined process. [GP114.SubP103]
4. Document the defined process and the records of the tailoring. [GP114.SubP104]
5. Revise the description of the defined process as necessary. [GP114.SubP106]

GP 2.6 Manage Configurations

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

The purpose of this generic practice is to establish and maintain the integrity of the designated work products of the process (or their descriptions) throughout their useful life. [GP109]

Refer to the Configuration Management process area for more information on placing work products under configuration management. *[GP109.R101]*

The designated work products are specifically identified in the plan for performing the process, along with a specification of the level of configuration management. [GP109.N101]

Different levels of configuration management are appropriate for different work products and for different points in time. 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 (which may be an individual, a group, or a team). [GP109.N102]

Sometimes, it may be critical that work products 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 of the designated work products. [GP109.N104]

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 points in time. [GP109.N103]

GP 2.7 Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders as planned.

The purpose of this generic practice is to establish and maintain the expected involvement of stakeholders during the execution of the process. [GP124]

Involve relevant stakeholders as described in an appropriate plan for stakeholder involvement. Involve them appropriately in activities such as the following: [GP124.N101]

- Planning
- Decisions
- Communications
- Coordination
- Reviews
- Appraisals
- Requirements definitions
- Resolution of problems/issues

Refer to the Project Planning process area for information on the project planning for stakeholder involvement. [GP124.N101.R101]

The objective of planning the stakeholder involvement is to ensure that interactions necessary to the process are accomplished, while not allowing excessive numbers of affected groups and individuals to impede process execution. [GP124.N102]

Subpractices

1. Identify stakeholders relevant to this process and decide what type of involvement should be practiced. [GP124.SubP101]

   Relevant stakeholders are identified among the suppliers of inputs to, the users of outputs from, and the performers of the activities within the process. Once the relevant stakeholders are identified, the appropriate level of their involvement in process activities is planned. [GP124.SubP101.N101]

2. Share these identifications with project planners or other planners as appropriate. [GP124.SubP102]

3. Involve relevant stakeholders as planned. [GP124.SubP103]

GP 2.8 Monitor and Control the Process

Monitor and control the process against the plan for performing the process and take appropriate corrective action.

The purpose of this generic practice is to perform the direct day-to-day monitoring and controlling of the process. Appropriate visibility into the process is maintained so that appropriate corrective action can be taken when necessary. Monitoring and controlling the process involves measuring appropriate attributes of the process or work products produced by the process. [GP110]

Refer to the Project Monitoring and Control process area for more information about monitoring and controlling the project and taking corrective action. [GP110.R102]

Refer to the Measurement and Analysis process area for more information about measurement. [GP110.R101]

Subpractices

1. Measure actual performance against the plan for performing the process. [GP110.SubP101]

   The measures are of the process, its work products, and its services. [GP110.SubP101.N101]

2. Review accomplishments and results of the process against the plan for performing the process. [GP110.SubP102]

3. Review activities, status, and results of the process with the immediate level of management responsible for the process and identify issues. The reviews are intended to provide the immediate level of management with appropriate visibility into the process. The reviews can be both periodic and event driven. [GP110.SubP108]

4. Identify and evaluate the effects of significant deviations from the plan for performing the process. [GP110.SubP104]

5. Identify problems in the plan for performing the process and in the execution of the process. [GP110.SubP105]

6. Take corrective action when requirements and objectives are not being satisfied, when issues are identified, or when progress differs significantly from the plan for performing the process. [GP110.SubP106]

   There are inherent risks that should be considered before any of the corrective actions are taken. [GP110.SubP106.N102]

   Corrective action may include the following: [GP110.SubP106.N101]

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

7. Track corrective action to closure. [GP110.SubP107]

GP 3.2 Collect Improvement Information

Collect work products, measures, measurement results, 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 generic practice is to collect information and artifacts derived from planning and performing the process. This generic practice is performed so that the information and artifacts can be included in the organizational process assets and made available to those who are (or who will be) planning and performing the same or similar processes. The information and artifacts are stored in the organization's measurement repository and the organization's process asset library. [GP117]

Examples of relevant information include the effort expended for the various activities, defects injected or removed in a particular activity, and lessons learned. [GP117.N101]

Refer to the Organizational Process Definition process area for more information about the organization's measurement repository and process asset library and for more information about the work products, measures, and improvement information that are incorporated into these organizational process assets. [GP117.N101.R101]

Subpractices

1. Store process and product measures in the organization's measurement repository. [GP117.SubP102]

   The process and product measures are primarily those that are defined in the common set of measures for the organization's set of standard processes.

   [GP117.SubP102.N101]

2. Submit documentation for inclusion in the organization's process asset library. [GP117.SubP103]

3. Document lessons learned from the process for inclusion in the organization's process asset library. [GP117.SubP104]

4. Propose improvements to the organizational process assets. [GP117.SubP101]

GP 2.9 Objectively Evaluate Adherence

Objectively evaluate adherence of the process against its process description, standards, and procedures, and address noncompliance.

The purpose of this generic practice is to provide credible assurance that the process is implemented as planned and adheres to its process description, standards, and procedures. See the definition of "objectively evaluate" in Appendix C, the glossary. [GP113]

People not directly responsible for managing or performing the activities of the process typically evaluate adherence. In many cases, adherence is evaluated by people within the organization, but external to the process or project, or by people external to the organization. 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). [GP113.N101]

Refer to the Process and Product Quality Assurance process area for more information about objectively evaluating adherence. [GP113.N101.R101]

GP 2.10 Review Status with Higher Level Management

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

The purpose of this generic practice is to provide higher level management with the appropriate visibility into the process. [GP112]

Higher level management includes those levels of management in the organization above the immediate level of management responsible for the process. In particular, higher level management includes senior management. These reviews are for managers who provide the policy and overall guidance for the process, not for those who perform the direct day-to-day monitoring and controlling of the process. [GP112.N102]

Different managers have different needs for information about the process. These reviews help ensure that informed decisions on the planning and performing of the process can be made. Therefore, these reviews are expected to be both periodic and event driven. [GP112.N101]

5 Framework Interactions

The CMMI Product Suite was developed using a consensus-based approach to identifying and describing best practices in a variety of disciplines. Successful process-improvement initiatives must be driven by the business objectives of the organization. [FM102.T103]

For example, a common business objective is to reduce the time it takes to get a product to market. The process-improvement objective derived from that might be to improve the Project Management processes to ensure on-time delivery and would be those found in the Project Planning and Project Monitoring and Control process areas. [FM102.T106]

In this chapter, interactions among process areas are described that help you to see the enterprise view of process improvement. The process areas discussed and illustrated include the IPPD material that is specific to models that include the IPPD discipline. If you are not using a model that includes IPPD, you may ignore the material that is specific to IPPD. Whenever possible, a statement is provided to let you know which information is specific to IPPD. [FM102.T101]

Where the Integrated Project Management (IPM) process area is mentioned in this chapter, it will refer to IPM for IPPD. Interactions of the IPM for IPPD process area with the Integrated Teaming (IT) and Organizational Environment for Integration (OEI) are described in this chapter. These process areas (IT and OEI) are only included if you have chosen IPPD. [FM102.T102]

Four Categories of CMMI Process Areas

Process areas can be grouped into four categories: [FM102.HDA101.T102]

- Process Management
- Project Management
- Engineering
- Support

Although we are grouping process areas this way to discuss their interactions, process areas often interact and have an effect on one another regardless of their defined group. For example, the Decision Analysis and Resolution process area provides specific practices addressing formal evaluation that are used in the Technical Solution process area for selecting a technical solution from alternative solutions. Technical Solution is an Engineering process area and Decision Analysis and Resolution is a Support process area. [FM102.HDA101.T103]

The Engineering process areas are written in a general engineering terminology so any technical discipline involved in the product development process (e.g., software engineering, mechanical engineering) can use them for process improvement. The Process Management, Project Management, and Support process areas also apply to all such disciplines, as well as others. [FM102.HDA101.T105]

You must be aware of the interactions that exist among CMMI model components to apply the model in a useful and productive way. The following sections describe those interactions. [FM102.HDA101.T106]

Process Management

The Scope of Process Management

Process Management process areas contain the cross-project activities related to defining, planning, resourcing, deploying, implementing, monitoring, controlling, appraising, measuring, and improving processes. [FM102.HDA102.HDB101.T102]

Remember to focus on the information relevant to your organization and included in the model you are using. [FM102.HDA102.HDB101.T103]

The Process Management process areas of CMMI are as follows: [FM102.HDA102.HDB101.T104]

- Organizational Process Focus
- Organizational Process Definition
- Organizational Training
- Organizational Process Performance
- Organizational Innovation and Deployment

To describe the interactions among the Process Management process areas, it is most useful to address them in two process area groups: [FM102.HDA102.HDB101.T105]

- The basic Process Management process areas are Organizational Process Focus, Organizational Process Definition, and Organizational Training.
- The advanced Process Management process areas are Organizational Process Performance and Organizational Innovation and Deployment.

Basic Process Management Process Areas

The basic Process Management process areas provide the organization with a basic capability to document and share best practices, organizational process assets, and learning across the organization. [FM102.HDA102.HDB102.T101]

Figure 2 provides a bird's-eye view of the interactions among the basic Process Management process areas and with other process area categories.[4] [FM102.HDA102.HDB102.T102]

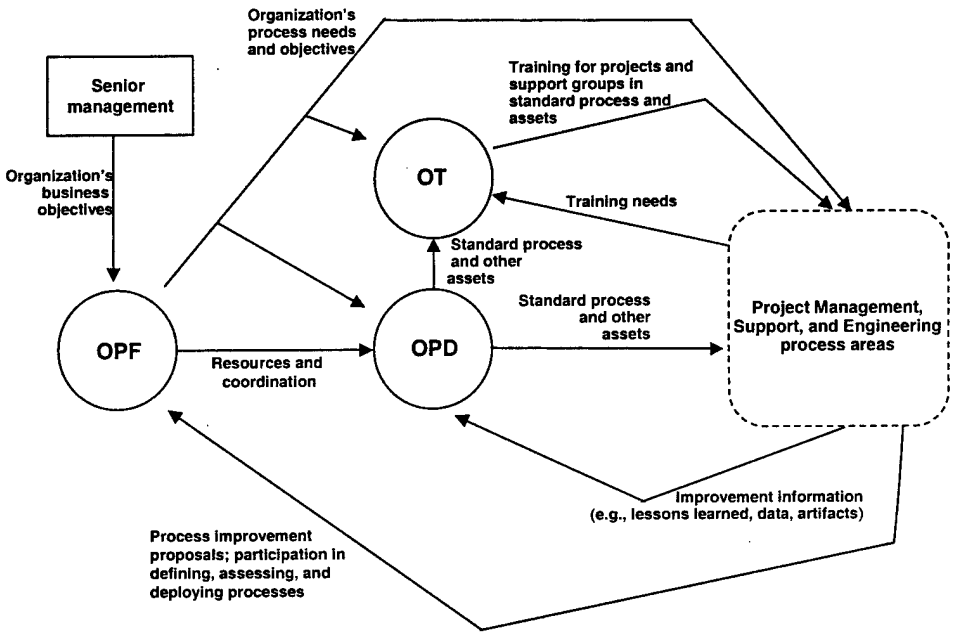


Figure 2: Basic Process Management Process Areas

[FM102.HDA102.HDB102.T103]

[4] See Appendix B for a complete list of process area abbreviations.

As illustrated in Figure 2, the Organizational Process Focus process area helps the organization to plan and implement organizational process improvement based on an understanding of the current strengths and weaknesses of the organization's processes and process assets. Candidate improvements to the organization's processes are obtained through various means. These include process-improvement proposals, measurement of the processes, lessons learned in implementing the processes, and results of process appraisal and product evaluation activities. [FM102.HDA102.HDB102.T104]

The Organizational Process Definition process area establishes and maintains the organization's set of standard processes and other assets based on the process needs and objectives of the organization. These other assets include descriptions of processes and process elements, descriptions of life-cycle models, process tailoring guidelines, process-related documentation, and data. Projects tailor the organization's set of standard processes to create their defined processes. The other assets support tailoring as well as implementation of the defined processes. Experiences and work products from performing these defined processes, including measurement data, process descriptions, process artifacts, and lessons learned, are incorporated as appropriate into the organization's set of standard processes and other assets. [FM102.HDA102.HDB102.T105]

The Organizational Training process area identifies the strategic training needs of the organization as well as the tactical training needs that are common across projects and support groups. In particular, training is developed or obtained that develops the skills required to perform the organization's set of standard processes. The main components of training include a managed training-development program, documented plans, personnel with appropriate knowledge, and mechanisms for measuring the effectiveness of the training program. [FM102.HDA102.HDB102.T108]

Advanced Process Management Process Areas

The advanced Process Management process areas provide the organization with an advanced capability to achieve its quantitative objectives for quality and process performance. [FM102.HDA102.HDB103.T101]

Figure 3 provides a bird's-eye view of the interactions among the advanced Process Management process areas and with other process area categories.[5] Each of the advanced Process Management process areas is strongly dependent on the ability to develop and deploy process and supporting assets. The basic Process Management process areas provide this ability. Thus, you should not try to reach a capability level for an advanced Process Management process area (up through capability level 3) prior to achieving that same capability level for all of the basic Process Management process areas.

[FM102.HDA102.HDB103.T103]

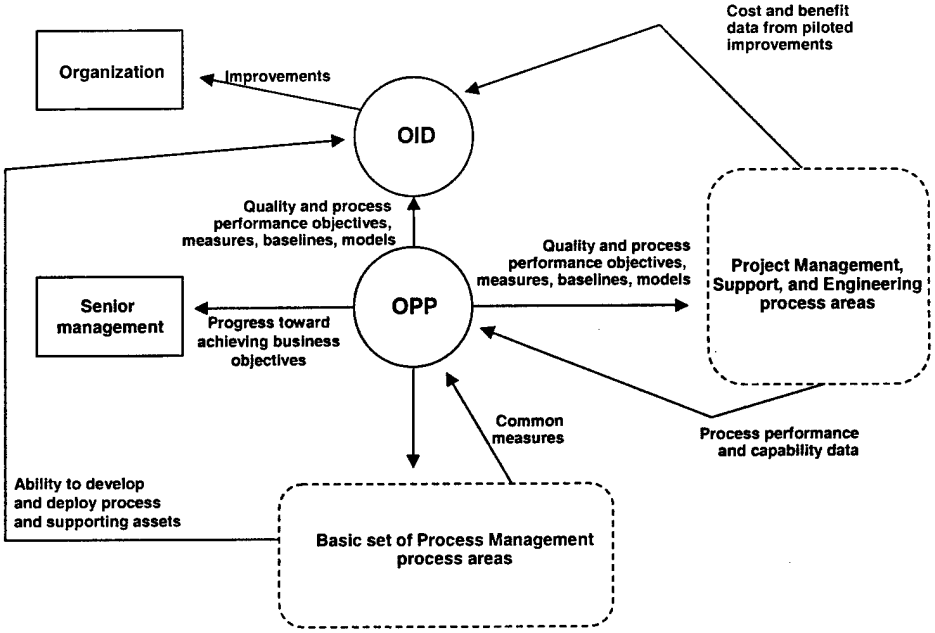


Figure 3: Advanced Process Management Process Areas

[FM102.HDA102.HDB103.T105]

As illustrated in Figure 3, the Organizational Process Performance process area derives quantitative objectives for quality and process performance from the organization's business objectives. The organization provides projects and support groups with common measures, process performance baselines, and process performance models. These additional organizational support assets support quantitative project management and statistical management of critical subprocesses for both projects and support groups. The organization analyzes the process performance data collected from these defined processes to develop a quantitative understanding of product quality, service quality, and process performance of the organization's set of standard processes. [FM102.HDA102.HDB103.T106]

[5] See Appendix B for a complete list of process area abbreviations.

The Organizational Innovation and Deployment process area selects and deploys proposed incremental and innovative improvements that improve the organization's ability to meet its quality and process-performance objectives. The identification of promising incremental and innovative improvements should involve the participation of an empowered workforce aligned with the business values and objectives of the organization. The selection of improvements to deploy is based on a quantitative understanding of the potential benefits and costs from deploying candidate improvements, and the available funding for such deployment. [FM102.HDA102.HDB103.T107]

Project Management

The Scope of Project Management

Project Management process areas cover the project management activities related to planning, monitoring, and controlling the project. [FM102.HDA103.HDB101.T107]

Remember to focus on the information relevant to your organization and included in the model you are using. [FM102.HDA103.HDB101.T108]

The Project Management process areas of CMMI are as follows: [FM102.HDA103.HDB101.T110]

- Project Planning
- Project Monitoring and Control
- Supplier Agreement Management
- Integrated Project Management for IPPD (or Integrated Project Management)
- Risk Management
- Integrated Teaming
- Quantitative Project Management

To describe the interactions among the Project Management process areas, it is most useful to address them in two process area groups: [FM102.HDA103.HDB101.T104]

- The basic Project Management process areas are Project Planning, Project Monitoring and Control, and Supplier Agreement Management.
- The advanced Project Management process areas are Integrated Project Management for IPPD, Risk Management, Integrated Teaming, and Quantitative Project Management.

Basic Project Management Process Areas

The basic Project Management process areas address the basic activities related to establishing and maintaining the project plan, establishing and maintaining commitments, monitoring progress against the plan, taking corrective action, and managing supplier agreements.

[FM102.HDA103.HDB102.T101]

Figure 4 provides a bird's-eye view of the interactions among the basic Project Management process areas and with other process area categories.[6] [FM102.HDA103.HDB102.T102]

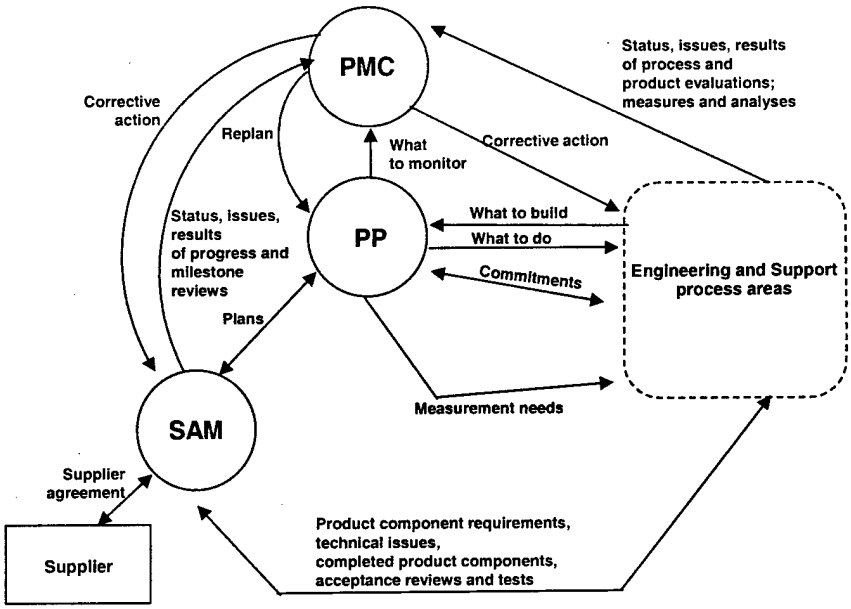


Figure 4: Basic Project Management Process Areas

[FM102.HDA103.HDB102.T104]

As illustrated in Figure 4, the Project Planning process area includes developing the project plan, involving stakeholders appropriately, obtaining commitment to the plan, and maintaining the plan. When using an IPPD approach, stakeholders represent not just the technical expertise for product and process development, but also the business implications of the product and process development.

[FM102.HDA103.HDB102.T106]

[6] See Appendix B for a complete list of process area abbreviations.

Planning begins with requirements that define the product and project ("What to Build" in the figure). The project plan covers the various project management and engineering activities that will be performed by the project. The project will review other plans that affect the project from various relevant stakeholders and establish commitments with those relevant stakeholders for their contributions to the project. For example, these plans cover process appraisals, product evaluations, configuration management, and measurement and analysis. [FM102.HDA103.HDB102.T107]

The Project Monitoring and Control process area includes monitoring activities and taking corrective action. The project plan specifies the appropriate level of project monitoring, the frequency of progress reviews, and the measures used to monitor progress. Progress is primarily determined by comparing progress to the plan. When actual status deviates significantly from the expected values, corrective actions are taken as appropriate. These actions may include re-planning. [FM102.HDA103.HDB102.T108]

The Supplier Agreement Management process area addresses the need of the project to effectively acquire those portions of work that are produced by suppliers. Once a product component is identified and the supplier who will produce it is selected, a supplier agreement is established and maintained that will be used to manage the supplier. The supplier's progress and performance are monitored. Acceptance reviews and tests are conducted on the supplier-produced product component. [FM102.HDA103.HDB102.T109]

Advanced Project Management Process Areas

The advanced Project Management process areas address activities such as establishing a defined process that is tailored from the organization's set of standard processes, coordinating and collaborating with relevant stakeholders, risk management, forming and sustaining integrated teams for the conduct of projects, and quantitatively managing the project's defined process. [FM102.HDA103.HDB103.T102]

Figure 5 provides a bird's-eye view of the interactions among the advanced Project Management process areas and with other process area categories. Each of the advanced Project Management process areas is strongly dependent on the ability to plan, monitor, and control the project. The basic Project Management process areas provide this ability.[7] [FM102.HDA103.HDB103.T103]

[7] See Appendix B for a complete list of process area abbreviations.

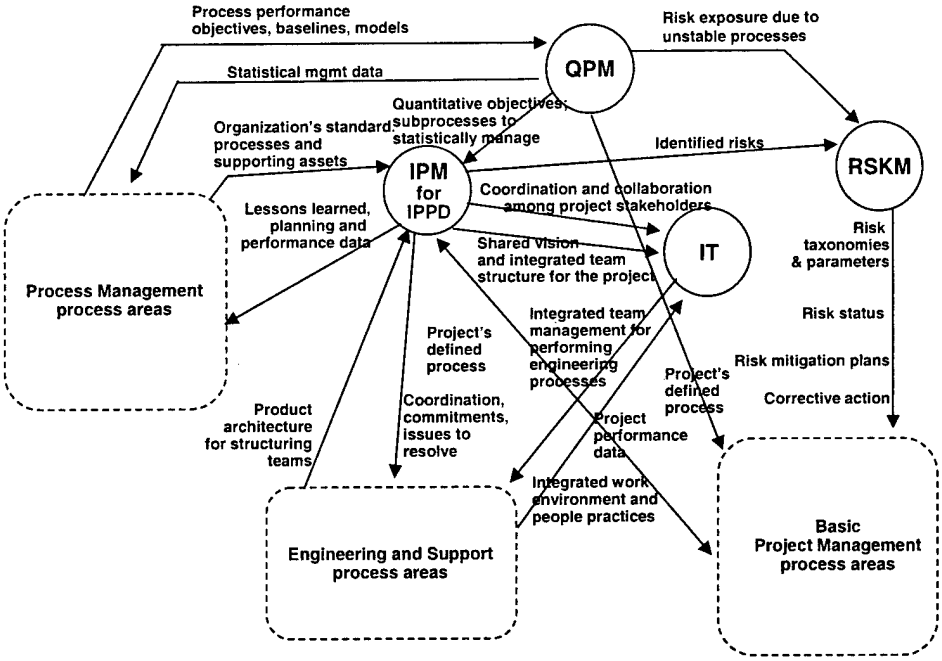


Figure 5: Advanced Project Management Process Areas

[FM102.HDA103.HDB103.T105]

Both versions of the Integrated Project Management process area (IPM and IPM for IPPD) establish and maintain the project's defined process that is tailored from the organization's set of standard processes. The project is managed using the project's defined process. The project uses and contributes to the organization's process assets.

[FM102.HDA103.HDB103.T108]

The project ensures that the relevant stakeholders associated with the project coordinate their efforts in a timely manner. It does this by providing for the management of stakeholder involvement; the identification, negotiation, and tracking of critical dependencies; and the resolution of coordination issues within the project with relevant stakeholders. [FM102.HDA103.HDB103.T110]

The following paragraph is only applicable to models containing IPPD.

[FM102.HDA103.HDB103.T120]

The Integrated Project Management for IPPD process area also creates the shared vision for the project. This shared vision should align both horizontally and vertically with both the organization's and integrated team's shared visions, created in the Organizational Environment for Integration and Integrated Teaming process areas, respectively. These shared visions collectively support the coordination and collaboration among stakeholders. Finally, the Integrated Project Management for IPPD process area implements an integrated team structure to perform the work of the project in developing a product. This team structure is typically based on the decomposition of the product itself, much like a work breakdown structure. This activity is accomplished in conjunction with the Integrated Teaming process area. [FM102.HDA103.HDB103.T111]

Although risk identification and monitoring are covered in the Project Planning and Project Monitoring and Control process areas, the Risk Management process area takes a more continuing, forward-looking approach to managing risks with activities that include identification of risk parameters, risk assessments, and risk handling.
[FM102.HDA103.HDB103.T112]

The Quantitative Project Management process area applies quantitative and statistical techniques to manage process performance and product quality. Quality and process-performance objectives for the project are based on those established by the organization. The project's defined process comprises, in part, process elements and subprocesses whose process performance can be predicted. At a minimum, the process variation experienced by subprocesses that is critical to achieving the project's quality and process-performance objectives is understood. Corrective action is taken when special causes of process variation are identified. See the definition of "special cause of process variation" in Appendix C, the glossary. [FM102.HDA103.HDB103.T114]

The following paragraph is only applicable to models containing IPPD.
[FM102.HDA103.HDB103.T121]

The specific practices in the Integrated Teaming process area provide for the formation and sustainment of each integrated team. Part of sustaining the team is developing the integrated team's shared vision, which must align with the project's and organization's shared visions, developed in the Integrated Project Management for IPPD and Organizational Environment for Integration process areas, respectively. The specific practices in the Organizational Environment for Integration and Integrated Teaming process areas then set the environment for enabling integrated teamwork. In addition, the Integrated Teaming process area interacts with other Project Management processes by supplying team commitments, work plans, and other information that forms the basis for managing the project and supporting risk management. [FM102.HDA103.HDB103.T116]

The Scope of Engineering

Engineering process areas cover the development and maintenance activities that are shared across engineering disciplines (e.g., systems engineering and software engineering). The six process areas in the Engineering process area category have inherent interrelationships. These interrelationships stem from applying a product development process rather than discipline-specific processes such as software engineering or systems engineering. [FM102.HDA104.HDB101.T101]

Remember to focus on the information relevant to your organization and included in the model you are using. [FM102.HDA104.HDB101.T103]

The Engineering process areas of CMMI are as follows:
[FM102.HDA104.HDB101.T102]

- Requirements Development
- Requirements Management
- Technical Solution
- Product Integration
- Verification
- Validation

Interactions Among Engineering Process Areas

The Engineering process areas integrate software-engineering and systems-engineering processes into a product-oriented process-improvement scenario. Improving product development processes targets essential business objectives, rather than specific disciplines. This approach to processes effectively avoids the tendency toward an organizational "stovepipe" mentality. [FM102.HDA104.HDB102.T101]

The technical foundation for IPPD is grounded in a robust systems-engineering approach that encompasses development in the context of the phases of the product's life, such as that provided in the Engineering process areas of the CMMI-SE/SW model. Thus, the implementation of IPPD provides amplifications to specific practices in the Engineering process areas that emphasize concurrent development and focus on all phases of the product's life. [FM102.HDA104.HDB102.T102]

The Engineering process areas apply to the development of any product or service in the engineering development domain (e.g., software products, hardware products, services, or processes).
[FM102.HDA104.HDB102.T103]

Figure 6 provides a bird's-eye view of the interactions among Engineering process areas.[8] [FM102.HDA104.HDB102.T104]

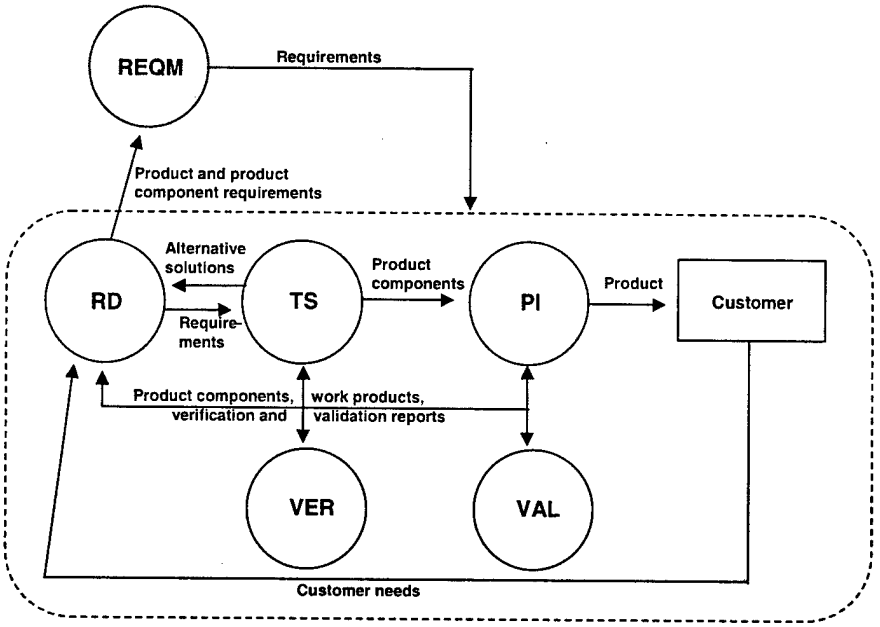


Figure 6: Engineering Process Areas [FM102.HDA104.HDB102.T106]

The Requirements Development process area identifies customer needs and translates these needs into product requirements. The set of product requirements is analyzed to produce a high-level conceptual solution. This set of requirements is then allocated to a set of product-component requirements. Other requirements that help define the product are derived and allocated to product components. This set of product and product-component requirements clearly describes the product's performance, design features, verification requirements, etc. in terms the developer understands and uses. [FM102.HDA104.HDB102.T124]

The Requirements Development process area supplies requirements to the Technical Solution process area, where the requirements are converted into the product architecture, product-component design, and the product component itself (e.g., coding, fabrication). Requirements are also supplied to the Product Integration process area, where product components are combined and interfaces are ensured to meet the interface requirements supplied by Requirements Development. [FM102.HDA104.HDB102.T111]

[8] See Appendix B for a complete list of process area abbreviations.

The Requirements Management process area maintains the requirements. It describes activities for obtaining and controlling requirement changes and ensuring that other relevant plans and data are kept current. It provides traceability of requirements from customer to product, to product component. [FM102.HDA104.HDB102.T112]

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. [FM102.HDA104.HDB102.T113]

The Technical Solution process area develops technical data packages for product components that will be used by the Product Integration process area. The examination of alternative 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 schedules. The task of selecting the final solution makes use of the specific practices in the Decision Analysis and Resolution process area. [FM102.HDA104.HDB102.T114]

The Technical Solution process area relies on the specific practices in the Verification process area to perform design verification and peer reviews during design and prior to final build. [FM102.HDA104.HDB102.T115]

The Verification process area ensures that selected work products meet the specified requirements. The Verification process area selects work products and verification methods that will be used to verify work products against specified requirements. Verification is generally an incremental process, starting with product-component verification and usually concluding with verification of fully assembled products. [FM102.HDA104.HDB102.T116]

Verification also addresses peer reviews. Peer reviews are a proven method for removing defects early and provide valuable insight into the work products and product components being developed and maintained. [FM102.HDA104.HDB102.T117]

The Validation process area incrementally validates products against the customer's needs. Validation may be performed in the operational environment or a simulated operational environment. Coordination with the customer on the validation requirements is one of the most essential elements of this process area. [FM102.HDA104.HDB102.T118]

The scope of the Validation process area includes validation of products, product components, selected intermediate work products, and processes. The product, product component, selected intermediate work product, or process may often require re-verification and re-validation. Issues discovered during validation are usually resolved in the Requirements Development or Technical Solution process areas. [FM102.HDA104.HDB102.T119]

The Product Integration process area establishes the expected specific practices associated with generating the best possible integration sequence, integrating product components and delivering the product to the customer. [FM102.HDA104.HDB102.T120]

Product Integration uses the specific practices of both Verification and Validation in implementing the product integration process. Verification verifies the interfaces and interface requirements between product components prior to product integration. This is an essential event in the integration process. During product integration in the operational environment, the specific practices of the Validation process area are used. [FM102.HDA104.HDB102.T121]

Engineering Process Areas and Recursion

All Engineering process areas have been written to support recursion throughout the product architecture. An example is the Establish Product Integration Procedures and Criteria specific practice in the Product Integration process area. For a product with many complex product components, this specific practice would be applied to the product components of the complete product delivered to the customer as well as to the product components assembled to form the product, and so on. Thus, this specific practice is applied to as many levels as necessary to integrate everything that the product comprises. [FM102.HDA104.HDB103.T101]

There is no specific practice that forces recursive process application. Rather, the specific practices are written in a fashion that "expects" process application throughout the product architecture. When implementing the specific practices of an Engineering process area, you must interpret them according to how they meet the needs of your product. You may be more comfortable viewing this approach as providing a sufficiently generic set of expectations that can be applied at any level of product detail rather than as enabling recursive behavior of a process. Either description of this approach is appropriate. [FM102.HDA104.HDB103.T103]

There are a number of advantages gained by this approach. For example, the Engineering process areas can be applied to a product that has several layers of product components and ensure that the specific practices will address each layer. Thus, different segments of a very large project can be appraised using the same model.

[FM102.HDA104.HDB103.T102]

Support

The Scope of Support

Support process areas cover the activities that support product development and maintenance. The Support process areas address processes that are used in the context of performing other processes. In general the Support process areas address processes that are targeted towards the project, and may address processes that apply more generally to the organization. For example, Process and Product Quality Assurance can be used with all the process areas to provide an objective evaluation of the processes and work products described in all of the process areas. [FM102.HDA105.HDB101.T101]

Remember to focus on the information relevant to your organization and included in the model you are using. [FM102.HDA105.HDB101.T104]

The Support process areas of CMMI are as follows: [FM102.HDA105.HDB101.T106]

- Configuration Management
- Process and Product Quality Assurance
- Measurement and Analysis
- Organizational Environment for Integration
- Decision Analysis and Resolution
- Causal Analysis and Resolution

To describe the interactions among the Support process areas, it is most useful to address them in two process area groups:

[FM102.HDA105.HDB101.T109]

- The basic Support process areas are Measurement and Analysis, Process and Product Quality Assurance, and Configuration Management.
- The advanced Support process areas are Organizational Environment for Integration, Causal Analysis and Resolution, and Decision Analysis and Resolution.

Basic Support Process Areas

The basic Support process areas address basic support functions that are used by all process areas. Although all Support process areas rely on the other process areas for inputs, the basic Support process areas provide support functions that are covered by generic practices.

[FM102.HDA105.HDB102.T101]

Figure 7 provides a bird's-eye view of the interactions among the basic Support process areas and with all other process areas.[9]

[FM102.HDA105.HDB102.T102]

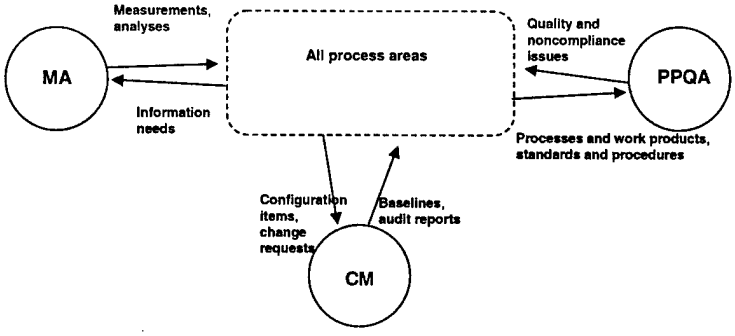


Figure 7: Basic Support Process Areas [FM102.HDA105.HDB102.T104]

The Measurement and Analysis process area supports all process areas by providing specific practices that guide projects and organizations in aligning measurement needs and objectives with a measurement approach that will provide objective results. These results can be used in making informed decisions and taking appropriate corrective actions. [FM102.HDA105.HDB102.T105]

[9] See Appendix B for a complete list of process area abbreviations.

The Process and Product Quality Assurance process area supports all process areas by providing specific practices for objectively evaluating performed processes, work products, and services against the applicable process descriptions, standards, and procedures and ensuring that any issues arising from these reviews are addressed. Process and Product Quality Assurance supports the delivery of high-quality products and services by providing the project staff and all levels of managers with appropriate visibility into, and feedback on, the processes and associated work products throughout the life of the project. [FM102.HDA105.HDB102.T106]

The Configuration Management process area supports all process areas by establishing and maintaining the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits. The work products placed under configuration management include the products that are delivered to the customer, designated internal work products, acquired products, tools, and other items that are used in creating and describing these work products. Examples of work products that may be placed under configuration management include plans, process descriptions, requirements, design data, drawings, product specifications, code, compilers, product data files, and product technical publications. [FM102.HDA105.HDB102.T107]

Advanced Support Process Areas

The advanced Support process areas provide the projects and organization with an advanced support capability. Each of these process areas relies on specific inputs or practices from other process areas. [FM102.HDA105.HDB103.T101]

Figure 8 provides a bird's-eye view of the interactions among the advanced Support process areas and with all other process areas.[10] [FM102.HDA105.HDB103.T102]

[10] See Appendix B for a complete list of process area abbreviations.

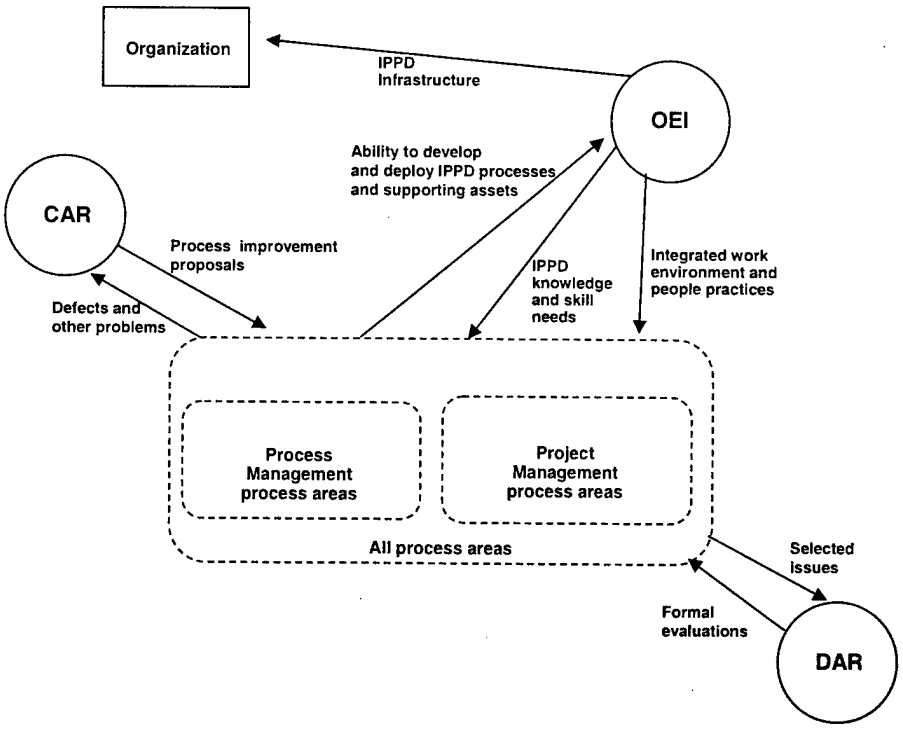


Figure 8: Advanced Support Process Areas [FM102.HDA105.HDB103.T105]

Using the Causal Analysis and Resolution process area, the project strives to understand the common causes of variation inherent in processes and remove them from the project's processes, as well as using this knowledge to continually improve the organization's processes. Both the defined processes and the organization's set of standard processes are targets of these improvement activities.
[FM102.HDA105.HDB103.T107]

The Decision Analysis and Resolution process area supports all the process areas by providing a formal evaluation process that ensures that alternatives are compared and the best one is selected to accomplish the goals of the process areas. [FM102.HDA105.HDB103.T108]

The following paragraph is only applicable to models containing IPPD.
[FM102.HDA105.HDB103.T110]

The Organizational Environment for Integration process area establishes the approach and environment for the implementation of IPPD. The environment is established by obtaining, adapting, or developing processes that facilitate effective integrated team behavior as well as stakeholder communication and collaboration, creating the organization's shared vision, and managing people to promote integrative behavior. Specific practices in the Organizational Environment for Integration process area promote both team and individual excellence while enabling and rewarding integration across all business and technical functions in the execution of the projects.

[FM102.HDA105.HDB103.T111]

6 Using CMMI Models

The CMMI project has worked to preserve the government and industry investments in process improvement and to enhance and replace 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 appraisal methods, and common training materials across the CMMI Product Suite. The objective of the CMMI project effort is to reduce the cost of establishing and maintaining process-improvement efforts across an enterprise using multiple disciplines to produce products or services. This chapter describes how organizations can use CMMI models for both process improvement and benchmarking. [FM120.T101]

Interpreting CMMI Models

Every CMMI model provides 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, acquiring, and maintaining products and services. While a new enterprise might wish to establish its processes using these concepts, the models are more commonly of interest to organizations that are seeking to improve their processes. [FM120.HDA101.T101]

Such organizations must 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 being used, the organization, the business environment, and the specific circumstances involved. [FM120.HDA101.T102]

CMMI practices purposely use nonspecific phrases such as "relevant stakeholders," "as appropriate," and "as necessary" to accommodate the needs of different organizations or projects. Specific needs may also differ at various points during a project's life. [FM120.HDA101.T103]

To interpret practices, it is important to consider the overall context in which they are used and determine how well the practices satisfy the goals of a process area within that context. CMMI models do not imply which processes are right for the organization or project. Instead, CMMI models establish minimal criteria necessary to plan and implement processes selected by the organization for improvement based on business objectives. [FM120.HDA101.T104]

Appraisals and Benchmarking

Process appraisals focus on identifying improvement opportunities. The organization should set its priorities based on its business and process-improvement objectives, as well as its collection of business and technical processes. Appraisal teams use CMMI models to guide them in identifying and prioritizing findings. These findings, with guidance provided by the practices in the CMMI models, are used (by a process group, for example) to plan improvements for the organization. In addition, many organizations find value in benchmarking their progress in process improvement for both internal purposes and with external customers and suppliers. [FM120.HDA102.T101]

For organizations that wish to appraise multiple disciplines, the integrated CMMI approach permits some economy of scale in model and appraisal training. One appraisal method can provide separate or combined results for multiple disciplines. [FM120.HDA102.T102]

The CMMI appraisal products also allow the appraisal of a single discipline (except for Integrated Product and Process Development), as in the past. CMMI appraisal products provide consistent ratings for staged and continuous representations. Equivalent staging enables organizations using a continuous representation to convert their appraisal ratings into a maturity level. [FM120.HDA102.T105]

The appraisal principles for the CMMI Product Suite remain the same as those used in past appraisals using many other process-improvement models. Those principles are: [FM120.HDA102.T106]

- Senior-management sponsorship
- A focus on the organization's business objectives
- Confidentiality for interviewees
- Use of a documented appraisal method
- Use of a process reference model (for example, a CMMI model) as a base
- A collaborative team approach
- A focus on actions for process improvement

Over time, a suite of appraisal techniques is expected to be developed by CMMI user-community members. New techniques will be developed and existing ones improved to meet various needs for building internal improvement. The CMMI project has produced one method to meet the need for a rigorous appraisal tool for benchmarking and a set of guidelines for future process-improvement appraisals requiring less rigor and repeatability. This most rigorous version has been named the Standard CMMI Appraisal Method for Process Improvement (SCAMPI[SM]). Details on this method are available on the Software Engineering Institute Web site at the following URL: <http://www.sei.cmu.edu/cmmi/products/assess.html>. [FM120.HDA102.T107]

For benchmarking against other organizations, appraisals must ensure consistent ratings. The achievement of a specific maturity level or the satisfaction of a process area must mean the same thing for different appraised organizations. Rules for ensuring this consistency are provided in the document mentioned above. SCAMPI is the only appraisal method initially considered to be suitable for rendering ratings for benchmarking using CMMI models. The SEI, as steward of the CMMI Product Suite, will ensure that any public comments or statements about maturity levels or ratings resulting from a SCAMPI appraisal meet quality and consistency criteria. [FM120.HDA102.T108]

SCAMPI was written to support the conduct of appraisals that conform to the emerging International Organization for Standardization and the International/Electrotechnical Commission (ISO/IEC) 15504 technical report. However, it is possible that a SCAMPI appraisal might not be 15504 conformant. ISO/IEC 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 ISO/IEC. For those sponsors interested in performing an ISO/IEC 15504-conformant appraisal, SCAMPI can support these needs. [FM120.HDA102.T109]

Appraisal Requirements for CMMI

The Appraisal Requirements for CMMI (ARC) document contains a set of criteria for developing, defining, and using appraisal methods based on CMMI products. The ARC provides requirements for multiple types of appraisal methods with guidelines for determining the suitability of a particular appraisal method. Suitability addresses the accuracy and repeatability of appraisal results. [FM120.HDA102.HDB101.T101]

[SM] SCAMPI is a service mark of Carnegie Mellon University.

The ARC document uses the CMMI models as its associated reference models. The CMM Appraisal Framework (CAF) v1.0 was originally produced to address appraisal methods associated with the CMM for Software only. With the incorporation of CMMs into the CMMI Framework, the ARC has been created to address these new models and the resulting impact of the staged and continuous representations. [FM120.HDA102.HDB101.T102]

The ARC document was designed to help improve consistency across multiple disciplines and appraisal methods, and to help appraisal method developers, sponsors, and users understand the tradeoffs associated with various methods. More information and a matrix detailing ARC requirements are available on the Software Engineering Institute's Web site. [FM120.HDA102.HDB101.T103]

Other CMMI-based appraisal methods may be appropriate for a given set of sponsor needs, including self assessments, initial appraisals, quick-look or mini appraisals, incremental appraisals, and external appraisals. Method developers are expected and encouraged to develop a variety of appraisal methods to meet these needs. [FM120.HDA102.HDB101.T104]

ISO/IEC 15504 Compatibility and Conformance

One objective that the CMMI Product Suite was designed to achieve is that of ISO/IEC 15504 compatibility and conformance. There are two aspects of conformance to the 1998 Technical Report version of ISO/IEC 15504: model compatibility and appraisal conformance. When the full international standard version of ISO/IEC 15504 is published (estimated to occur in 2003), there will be some changes to what ISO/IEC 15504 conformance means. [FM120.HDA102.HDB102.T101]

For an appraisal model (for example, Bootstrap, CMMI-SE/SW, and so on) to claim to be ISO/IEC 15504 conformant (an ISO/IEC 15504-compatible model), a "demonstration of compatibility" document would need to show how the model compatibility requirements of ISO/IEC 15504-2 have been addressed. These requirements are constructed to provide reasonable assurance that the model will work properly with the associated documented appraisal process (appraisal method). [FM120.HDA102.HDB102.T102]

There are also ISO/IEC 15504 requirements that pertain to the actual conduct (planning as well as performance) of an appraisal. If the conduct of an appraisal is such that the requirements in ISO/IEC 15504-3 are satisfied, then the appraisal is said to be ISO/IEC 15504 conformant. One of these requirements is that a ISO/IEC 15504-compatible appraisal model is used. [FM120.HDA102.HDB102.T103]

Making the Transition to CMMI

This section briefly describes three transition scenarios. The first two assume the organization has already begun its improvement efforts using either the Software CMM or the Electronic Industries Alliance Interim Standard (EIA/IS) 731. The third scenario assumes that the organization has not used a particular reference model for current improvement efforts, or that there have been no improvement efforts to date. [FM120.HDA103.T101]

Organizations with Software CMM Experience

Many organizations initially making the transition to CMMI will likely be seeking to update their process-improvement efforts to incorporate the Version 2.0 draft C improvements and to gain the additional breadth of coverage afforded in CMMI models. Many of these organizations will need to decide the best timing for transition to preserve the value of plans toward, for example, achievement of a particular maturity level. [FM120.HDA103.HDB102.T101]

Organizations that have already achieved a high level of maturity may wish to make the transition more quickly to take advantage of the additional organizational coverage described in CMMI models. These organizations will find strong commonality between CMMI models and the Software CMM. Also, there is significant improvement in coverage of the engineering, risk management, and measurement and analysis processes, as compared to the Software CMM. [FM120.HDA103.HDB102.T102]

The Software CMM practices at maturity levels 4 and 5 have been improved based on experience gained since the publication of SW-CMM Version 2 draft C. These practices have been further refined from the source model based on studies conducted by the SEI that analyzed the implementation of maturity level 4 and 5 practices by leading organizations. [FM120.HDA103.HDB102.T103]

Organizations that have begun significant effort toward a maturity level 2, 3, or 4 appraisal must weigh the costs of making the transition against the benefits of the improved coverage an integrated model offers. [FM120.HDA103.HDB102.T104]

Organizations may wish to consider the versatility offered by the continuous and staged representations in planning their long-term appraisal and improvement approaches. If the costs of total transition appear high, an interim approach might be to augment their current plan with selected process areas that would be of greatest business value. [FM120.HDA103.HDB102.T105]

For example, a company with several months remaining before a maturity level 4 appraisal might want to charter small teams to investigate Risk Management and Measurement and Analysis, and add them to the appraisal scope to begin the transition without affecting current efforts. This long-term improvement approach allows members of the organization to have a "first look" at new process areas and to gain insight that helps them build business value in these two process areas as well as preparing them for future CMMI appraisals.
[FM120.HDA103.HDB102.T106]

Organizations with EIA/IS 731 Experience

Organizations that have framed their process-improvement efforts around systems-engineering models have similar choices to make, depending upon their progress on current improvement efforts.
[FM120.HDA103.HDB107.T101]

The evolution from Electronic Industries Alliance Interim Standard (EIA/IS) 731 involves (1) some reorganization of specific practices under specific goals and process areas and (2) the addition of informative material. Initial transition steps therefore might be to compare current improvement efforts against those now expected in the CMMI models. [FM120.HDA103.HDB107.T102]

Organizations New to CMM-Type Models

Organizations without experience in either SW-CMM or EIA/IS 731 are assumed to be in one of two categories. They may have undertaken process-improvement efforts under other quality initiatives such as ISO 9000 or Malcolm Baldrige, or they may be considering such efforts because of the mounting evidence of business value resulting from such a commitment. [FM120.HDA103.HDB104.T101]

Both categories of organizations will find familiar relationships to other quality efforts in the CMMI Product Suite. They also gain reference models of effective practices that can be applied—across the value chain—to enhance the quality of products and their associated processes. [FM120.HDA103.HDB104.T102]

These organizations may approach improvement by using either a continuous or staged representation. Each approach is complementary to the other. Neither is mutually exclusive, but the choice will affect the schedule and needs of the organization for training and appraisal. See the Model Representation Comparison section in Chapter 2 for more information about selecting a CMMI model representation.
[FM120.HDA103.HDB104.T103]

Once your organization has decided which representation is the best fit, planning can begin with an improvement approach such as the Initiating, Diagnosing, Establishing, Acting, Learning (IDEAL[SM]) model. (For more information about the IDEAL model, see the Web site <http://www.sei.cmu.edu/ideal/ideal.html>.) Research has shown that the most powerful initial step to process improvement is to build strong organizational sponsorship during the Initiating phase prior to investing in significant diagnostic efforts. [FM120.HDA103.HDB104.T104]

Given sufficient senior-management sponsorship, establishing a specific, technically competent process group to guide process-improvement efforts has proven to be a best practice. For an organization whose mission is to develop software-intensive systems, the group might include systems engineers and software engineers from projects across the organization, and other selected members based on the business needs driving improvement. For example, a systems administrator may focus on information-technology support, whereas a marketing representative may focus on integrating customer needs. Both members could make powerful additions to the process group. [FM120.HDA103.HDB104.T105]

Training

Training is a key element in the ability of organizations to adopt CMMI and is therefore a key part of the product suite. While an initial set of courses is provided by the SEI and its transition partners, your organization may wish to supplement these courses with internal instruction. This approach allows the organization to focus on the areas that provide the greatest business value. [FM120.HDA103.HDB105.T101]

Initial training is available for both representations of CMMI models. Training is also provided to assist those who plan to guide improvement as part of a process group, or those seeking to become lead appraisers. [FM120.HDA103.HDB105.T102]

Tailoring Perspectives

Tailoring a CMMI model is a process whereby only a subset of a model is used to suit the needs of a specific domain of application. [FM120.HDA105.T101]

[SM] IDEAL is a service mark of Carnegie Mellon University.

Tailoring the CMMI appraisal method involves the selection of options for use in an appraisal. 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 focusing on those aspects of the products and services that are most beneficial to the organization. [FM120.HDA105.T102]

The tailoring discussed in this section does not address adaptation of an organization's set of standard processes for use on a specific project. Such tailoring is driven by tailoring guidelines defined by an organization. [FM120.HDA105.T103]

Model Tailoring

Model tailoring should only be done knowing that it can result in significant gaps in efforts to improve or appraise an organization's or a project's capabilities. [FM120.HDA104.T101]

Model Tailoring Perspectives

Tailoring of a CMMI model can be viewed from two perspectives: [FM120.HDA104.HDB101.T101]

- Model tailoring related to use of a model for process improvement
- Model tailoring related to use of a model for benchmarking

Many organizations will use a CMMI model for benchmarking as well as process improvement. Such tailoring is constrained by the intersection of criteria outlined in the next two sections. [FM120.HDA104.HDB101.T102]

Model Tailoring Criteria for Internal Process Improvement

For internal process improvement, it is appropriate to restrict or expand the scope of an organization's or project's improvement effort (including appraisals). The tailoring may address individual disciplines, process areas, maturity levels, and/or capability levels. Tailoring of a model should focus on identifying the process areas and practices that support an organization's business needs and objectives. [FM120.HDA104.HDB102.T101]

Care must be taken when considering whether to exclude portions of a CMMI model. Given a CMMI model's focus on the essential characteristics of an effective process, the majority of the process areas and practices in a model typically would be addressed. In fact, the wholesale exclusion of fundamental processes or specific practices is discouraged, 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 schedule objectives. [FM120.HDA104.HDB102.T102]

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

[FM120.HDA104.HDB102.T103]

Model Tailoring Criteria for Benchmarking

Use of CMMI models for benchmarking purposes allows for comparison of process appraisal results across an industry via state-of-the-practice reports or across a group of organizations such as potential suppliers. Any tailoring applied in this way must ensure consistency in the ratings resulting from the use of models in multiple appraisals. As a result, model tailoring for benchmarking is significantly constrained, especially where maturity levels resulting from appraisals are disseminated publicly for marketing purposes. [FM120.HDA104.HDB103.T101]

Keep in mind that the scope chosen for an appraisal also affects the context of benchmarking. If one organization chooses to appraise only software engineering while another chooses to appraise software and systems engineering, comparing the two would not be fair or accurate. Model tailoring criteria for benchmarking are defined as follows:

[FM120.HDA104.HDB103.T102]

- Process areas include required and expected model components and thus may not be excluded other than to omit those that are outside the scope of an appraisal. For example, when an organization uses a staged representation, process areas at maturity levels 4 and 5 may be omitted for an appraisal focused on maturity level 3, whereas all process areas for maturity levels 2 and 3 would typically be selected. When using a continuous representation, process areas outside the scope of the target profile may be omitted, but doing so will compromise the benchmarking opportunities provided by equivalent staging.

- Process areas, in some circumstances, may be determined to be "not applicable" if the process area is, in fact, outside of the organization's scope of work. An example of a process area that might be excluded from an appraisal using a staged representation would be Supplier Agreement Management, a process area that may not be applicable in the absence of suppliers of products and services external to the organization that are critical to the development effort. A maturity level rating could still be determined; however, that maturity level rating must also include mention of the "not applicable" process area. Conversely, when using a continuous representation, process areas may be selected for exclusion if they are not within the organization's scope of work or of the process-improvement effort. Care must be taken, however, that process areas providing the foundation for other process areas important to the organization are not excluded. Furthermore, even though an organization uses a continuous representation, if it wishes to use equivalent staging it must adhere to the tailoring guidelines practiced by users of the staged representation.
- A process area is designated as "not rated" if it is outside the appraisal scope or if insufficient data is available to satisfy the data-coverage criteria. A maturity level cannot be determined if process areas at that maturity level (or below) are "not rated."
- Goals are required and thus cannot be excluded from those process areas included in the scope of a process-improvement or appraisal effort. Goals reflect the minimum requirements for satisfying a process area. If a process area is applicable, each of its goals is applicable. Goals work together to support a process area and may not be individually designated as "not applicable."
- Specific practices and generic practices are expected to be implemented as typical activities necessary to implement and institutionalize the goals of the process area. However, appropriate alternative practices may be substituted for specific practices and/or generic practices if the alternatives are effective in implementing and institutionalizing the goals.
- All other model components (subpractices, examples, amplifications, elaborations, and/or references) contained in CMMI models are informative and are provided solely for guidance in implementation.

Model Tailoring for Smaller Projects

The CMMI models were written for use by all types of organizations; however, for small organizations a CMMI model must be interpreted. In the case of small, three- to six-month projects, a high-level plan is typically available that has been developed for a group of projects. This high-level plan defines the organization, resources, training, management participation, and quality assurance reporting descriptions for all projects. [FM120.HDA104.HDB104.T101]

Conversely, in the project plan, the detailed planning of the project, such as the schedule, tasks, and resources, are defined. Often the project plan also contains plans for other supporting functions, such as quality assurance and configuration management. A four-person project might expect to develop a project plan that is only a few pages long. [FM120.HDA104.HDB104.T102]

In small projects, meetings take place more frequently, take less time, and cover more details. The schedule may contain daily activities, and may be monitored in weekly meetings. The schedule may change weekly and be controlled. [FM120.HDA104.HDB104.T104]

In a small team, the customer usually knows the entire team and feels comfortable calling any member of the team to propose or discuss a change. The team must decide up front how to handle these informal calls from the customer. Once team members have decided on an approach, it should be documented and communicated to the customer. [FM120.HDA104.HDB104.T105]

Appraisal Tailoring

The major appraisal-tailoring options for a CMMI appraisal include the following: [FM120.HDA104.HDB105.T101]

- Establishing the appraisal scope, including the organizational entity to be appraised, the CMMI process areas to be investigated, and the level to be appraised
- Selecting the appraisal method
- Selecting the appraisal team members
- Selecting appraisal participants from the appraisal entity to be interviewed
- Establishing appraisal outputs (for example, ratings, instantiation-specific findings)
- Establishing appraisal constraints (for example, time spent on site)

In addition to these appraisal-tailoring options, the CMMI appraisal method description details a number of specific appraisal-tailoring options driven by considering the objectives of a particular appraisal and the business objectives of the organization and/or instantiation. Documentation of CMMI appraisal plans and results must always include a description of the appraisal-tailoring options selected, as well as any model tailoring. Such documentation will enable a determination to be made of the comparability of appraisal results across organizations. [FM120.HDA104.HDB105.T102]

7 Process Areas

MATURITY LEVEL 2: MANAGED

The following section contains all of the process areas that belong to maturity level 2. The maturity level 2 process areas of CMMI are as follows: [FM109.T101]

- Requirements Management
- Project Planning
- Project Monitoring and Control
- Supplier Agreement Management
- Measurement and Analysis
- Process and Product Quality Assurance
- Configuration Management

See Chapter 2 for more information about CMMI maturity levels. [FM109.T103]

REQUIREMENTS MANAGEMENT

Maturity Level 2

Purpose

The purpose of Requirements Management is to manage the requirements of the project's products and product components and to identify inconsistencies between those requirements and the project's plans and work products. [PA146]

Introductory Notes

Requirements management processes manage all requirements received or generated by the project, including both technical and nontechnical requirements as well as those requirements levied on the project by the organization. In particular, if the Requirements Development process area is implemented, its processes will generate product and product-component requirements that will also be managed by the requirements management processes. When the Requirements Management, Requirements Development, and Technical Solution process areas are all implemented, their associated processes may be closely tied and be performed concurrently. [PA146.N101]

The project takes appropriate steps to ensure that the agreed-upon set of requirements is managed to support the planning and execution needs of the project. When a project receives requirements from an approved requirements provider, the requirements are reviewed with the requirements provider to resolve issues and prevent misunderstanding before the requirements are incorporated into the project's plans. Once the requirements provider and the requirements receiver reach an agreement, commitment to the requirements is obtained from the project participants. The project manages changes to the requirements as they evolve and identifies any inconsistencies that occur among the plans, work products, and requirements. [PA146.N102]

Part of the management of requirements is to document requirements changes and rationale and maintain bidirectional traceability between source requirements and all product and product-component requirements. [PA146.N103]

Related Process Areas

Refer to the Requirements Development process area for more information regarding transforming stakeholder needs into product requirements and deciding how to allocate or distribute requirements among the product components. [PA146.R101]

Refer to the Technical Solution process area for more information about transforming requirements into technical solutions. [PA146.R102]

Refer to the Project Planning process area for more information about how project plans reflect requirements and need to be revised as requirements change. [PA146.R103]

Refer to the Configuration Management process area for more information about baselines and controlling changes to configuration documentation for requirements. [PA146.R104]

Refer to the Project Monitoring and Control process area for more information about tracking and controlling the activities and work products that are based on the requirements and taking appropriate corrective action. [PA146.R105]

Refer to the Risk Management process area for more information about identifying and handling risks associated with requirements. [PA146.R106]

Specific and Generic Goals

SG 1 **Manage Requirements** [PA146.IG101]

Requirements are managed and inconsistencies with project plans and work products are identified.

GG 2 **Institutionalize a Managed Process** [CL103.GL101]

The process is institutionalized as a managed process.

(The following goal is not required for maturity level 2, but required for maturity level 3 and above.)

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Manage Requirements [PA146.IG101]

SP 1.1		Obtain an Understanding of Requirements
SP 1.2		Obtain Commitment to Requirements
SP 1.3		Manage Requirements Changes
SP 1.4		Maintain Bidirectional Traceability of Requirements
SP 1.5		Identify Inconsistencies between Project Work and Requirements

GG 2 Institutionalize a Managed Process [CL103.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 2.2	(AB 1)	Plan the Process
GP 2.3	(AB 2)	Provide Resources
GP 2.4	(AB 3)	Assign Responsibility
GP 2.5	(AB 4)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

(The following goal is not required and its practices are not expected for a maturity level 2 rating, but are required and expected for a maturity level 3 rating and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 3.1	Establish a Defined Process
GP 3.2	Collect Improvement Information

Specific Practices by Goal

SG 1 Manage Requirements

Requirements are managed and inconsistencies with project plans and work products are identified. *[PA146.IG101]*

The project maintains a current and approved set of requirements over the life of the project by doing the following: [PA146.IG101.N101]

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

Refer to the Technical Solution process area for more information about determining the feasibility of the requirements. *[PA146.IG101.N101.R101]*

Refer to the Requirements Development process area for more information about ensuring that the requirements reflect the needs and expectations of the customer. [PA146.IG101.N101.R102]

Refer to the Project Monitoring and Control process area for more information about taking corrective action. [PA146.IG101.N101.R103]

For Software Engineering

The requirements may be a subset of the overall product requirements, or they may constitute the entire product requirements. [PA146.IG101.AMP101]

For Systems Engineering

Each level of product-component design (e.g., segment, subsystem) receives the requirements from the higher level. [PA146.IG101.AMP102]

SP 1.1 Obtain an Understanding of Requirements

Develop an understanding with the requirements providers on the meaning of the requirements. [PA146.IG101.SP101]

As the project matures and requirements are derived, all activities or disciplines will receive requirements. To avoid requirements creep, criteria are established to designate appropriate channels, or official sources, from which to receive requirements. The receiving activities conduct analyses of the requirements with the requirements provider to ensure that a compatible, shared understanding is reached on the meaning of the requirements. The result of this analysis and dialog is an agreed-to set of requirements. [PA146.IG101.SP101.N101]

Typical Work Products

1. Lists of criteria for distinguishing appropriate requirements providers [PA146.IG101.SP101.W101]
2. Criteria for evaluation and acceptance of requirements [PA146.IG101.SP101.W102]
3. Results of analyses against criteria [PA146.IG101.SP101.W103]
4. An agreed-to set of requirements [PA146.IG101.SP101.W104]

Subpractices

1. Establish criteria for distinguishing appropriate requirements providers. [PA146.IG101.SP101.SubP101]
2. Establish objective criteria for the acceptance of requirements. [PA146.IG101.SP101.SubP102]

Lack of acceptance criteria often results in inadequate verification, costly rework, or customer rejection. [PA146.IG101.SP101.SubP102.N102]

Examples of acceptance criteria include the following: [PA146.IG101.SP101.SubP102.N101]

- Clearly and properly stated
- Complete
- Consistent with each other
- Uniquely identified
- Appropriate to implement
- Verifiable (testable)
- Traceable

3. Analyze requirements to ensure that the established criteria are met. [PA146.IG101.SP101.SubP103]

4. Reach an understanding of the requirements with the requirements provider so the project participants can commit to them. [PA146.IG101.SP101.SubP104]

SP 1.2 Obtain Commitment to Requirements

Obtain commitment to the requirements from the project participants. *[PA146.IG101.SP102]*

Refer to the Project Monitoring and Control process area for more information about monitoring the commitments made. *[PA146.IG101.SP102.R101]*

For Integrated Product and Process Development

When integrated teams are formed, the project participants are the integrated teams and their members. Commitment to the requirement for interacting with other integrated teams is as important for each integrated team as its commitments to product and other project requirements. *[PA146.IG101.SP102.AMP101]*

Whereas the previous specific practice dealt with reaching an understanding with the requirements providers, this specific practice deals with agreements and commitments among those who have to carry out the activities necessary to implement the requirements. Requirements evolve throughout the project, especially as described by the specific practices of the Requirements Development process area and the Technical Solution process area. As the requirements evolve, this specific practice ensures that project participants commit to the current, approved requirements and the resulting changes in project plans, activities, and work products. [PA146.IG101.SP102.N101]

Typical Work Products

1. Requirements impact assessments [PA146.IG101.SP102.W101]
2. Documented commitments to requirements and requirements changes [PA146.IG101.SP102.W102]

Subpractices

1. Assess the impact of requirements on existing commitments. [PA146.IG101.SP102.SubP101]

   The impact on the project participants should be evaluated when the requirements change or at the start of a new requirement. [PA146.IG101.SP102.SubP101.N101]

2. Negotiate and record commitments. [PA146.IG101.SP102.SubP102]

   Changes to existing commitments should be negotiated before project participants commit to the requirement or requirement change. [PA146.IG101.SP102.SubP102.N101]

SP 1.3 Manage Requirements Changes

Manage changes to the requirements as they evolve during the project. *[PA146.IG101.SP103]*

Refer to the Configuration Management process area for more information about maintaining and controlling the requirements baseline and on making the requirements and change data available to the project. *[PA146.IG101.SP103.R101]*

During the project, requirements change for a variety of reasons. As needs change and as work proceeds, additional requirements are derived and changes may have to be made to the existing requirements. It is essential to manage these additions and changes efficiently and effectively. To effectively analyze the impact of the changes, it is necessary that the source of each requirement is known and the rationale for any change is documented. The project manager may, however, want to track appropriate measures of requirements volatility to judge whether new or revised controls are necessary. [PA146.IG101.SP103.N101]

Typical Work Products

1. Requirements status [PA146.IG101.SP103.W101]
2. Requirements database [PA146.IG101.SP103.W102]
3. Requirements decision database [PA146.IG101.SP103.W103]

Subpractices

1. Capture all requirements and requirements changes that are given to or generated by the project. [PA146.IG101.SP103.SubP101]

2. Maintain the requirements change history with the rationale for the changes. [PA146.IG101.SP103.SubP102]

   Maintaining the change history helps track requirements volatility. [PA146.IG101.SP103.SubP102.N101]

3. Evaluate the impact of requirement changes from the standpoint of relevant stakeholders. [PA146.IG101.SP103.SubP103]

4. Make the requirements and change data available to the project. [PA146.IG101.SP103.SubP104]

SP 1.4 Maintain Bidirectional Traceability of Requirements

Maintain bidirectional traceability among the requirements and the project plans and work products. *[PA146.IG101.SP104]*

The intent of this specific practice is to maintain the bidirectional traceability of requirements for each level of product decomposition. When the requirements are managed well, traceability can be established from the source requirement to its lower level requirements and from the lower level requirements back to their source. Such bidirectional traceability helps determine that all source requirements have been completely addressed and that all lower level requirements can be traced to a valid source. Requirements traceability can also cover the relationships to other entities such as intermediate and final work products, changes in design documentation, test plans, and work tasks. The traceability should cover both the horizontal and vertical relationships, such as across interfaces. Traceability is particularly needed in conducting the impact assessment of requirements changes on the project plans, activities, and work products. [PA146.IG101.SP104.N101]

Typical Work Products

1. Requirements traceability matrix [PA146.IG101.SP104.W101]
2. Requirements tracking system [PA146.IG101.SP104.W102]

Subpractices

1. Maintain requirements traceability to ensure that the source of lower level (derived) requirements is documented. [PA146.IG101.SP104.SubP101]
2. Maintain requirements traceability from a requirement to its derived requirements as well as to its allocation of functions, objects, people, processes, and work products. [PA146.IG101.SP104.SubP102]
3. Maintain horizontal traceability from function to function and across interfaces. [PA146.IG101.SP104.SubP103]
4. Generate the requirements traceability matrix. [PA146.IG101.SP104.SubP104]

SP 1.5 Identify Inconsistencies between Project Work and Requirements

Identify inconsistencies between the project plans and work products and the requirements. *[PA146.IG101.SP105]*

Refer to the Project Monitoring and Control process area for more information about monitoring and controlling the project plans and work products for consistency with requirements and taking corrective actions when necessary. *[PA146.IG101.SP105.R101]*

This specific practice finds the inconsistencies between the requirements and the project plans and work products and initiates the corrective action to fix them. [PA146.IG101.SP105.N101]

Typical Work Products

1. Documentation of inconsistencies including sources, conditions, and rationale [PA146.IG101.SP105.W101]
2. Corrective actions [PA146.IG101.SP105.W102]

Subpractices

1. Review the project's plans, activities, and work products for consistency with the requirements and the changes made to them. [PA146.IG101.SP105.SubP101]
2. Identify the source of the inconsistency and the rationale. [PA146.IG101.SP105.SubP102]
3. Identify changes that need to be made to the plans and work products resulting from changes to the requirements baseline. [PA146.IG101.SP105.SubP103]
4. Initiate corrective actions. [PA146.IG101.SP105.SubP104]

GG 2 Institutionalize a Managed Process [CL103.GL101]

The process is institutionalized as a managed process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the requirements management process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for managing requirements and identifying inconsistencies between the requirements and the project plans and work products. [PA146.EL101]

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the plan for performing the requirements management process. *[GP104]*

Elaboration:

Typically, this plan for performing the requirements management process is a part of the project plan as described in the Project Planning process area. [PA146.EL102]

GP 2.3 (AB 2) Provide Resources

Provide adequate resources for performing the requirements management process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Examples of resources provided include the following tools: [PA146.EL113]

- Requirements tracking tools
- Traceability tools

GP 2.4 (AB 3) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the requirements management process. *[GP106]*

GP 2.5 (AB 4) Train People

Train the people performing or supporting the requirements management process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA146.EL105]

- Application domain
- Requirements definition, analysis, review, and management
- Requirements management tools
- Configuration management
- Negotiation and conflict resolution

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the requirements management process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA146.EL108]

- Requirements
- Requirements traceability matrix

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the requirements management process as planned. *[GP124]*

Elaboration:

Select relevant stakeholders from customers, end users, developers, producers, testers, suppliers, marketers, maintainers, disposal personnel, and others who may be affected by, or may affect, the product as well as the process. [PA146.EL115]

Examples of activities for stakeholder involvement include: [PA146.EL116]

- Resolving issues on the understanding of the requirements
- Assessing the impact of requirements changes
- Communicating the bidirectional traceability
- Identifying inconsistencies among project plans, work products, and requirements

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the requirements management process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA146.EL111]

- Requirements volatility (percentage of requirements changed)

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the requirements management process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA146.EL112]

- Managing requirements
- Identifying inconsistencies among project plans, work products, and requirements

Examples of work products reviewed include the following: [PA146.EL114]

- Requirements
- Requirements traceability matrix

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the requirements management process with higher level management and resolve issues. *[GP112]*

Elaboration:

Proposed changes to commitments to be made external to the organization are reviewed with higher level management to ensure that all commitments can be accomplished. [PA146.EL117]

(The following goal is not required and its practices are not expected for a maturity level 2 rating, but are required for a maturity level 3 rating and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

GP 3.1 Establish a Defined Process

Establish and maintain the description of a defined requirements management process. *[GP114]*

GP 3.2 Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the requirements management process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

PROJECT PLANNING

Maturity Level 2

Purpose

The purpose of Project Planning is to establish and maintain plans that define project activities. [PA163]

Introductory Notes

The Project Planning process area involves the following: [PA163.N101]

- Developing the project plan
- Interacting with stakeholders appropriately
- Getting commitment to the plan
- Maintaining the plan

Planning begins with requirements that define the product and project. [PA163.N102]

Planning includes estimating the attributes of the work products and tasks, determining the resources needed, negotiating commitments, producing a schedule, and identifying and analyzing project risks. Iterating through these activities may be necessary to establish the project plan. The project plan provides the basis for performing and controlling the project's activities that address the commitments with the project's customer. [PA163.N103]

The project plan will usually need to be revised as the project progresses to address changes in requirements and commitments, inaccurate estimates, corrective actions, and process changes. Specific practices describing both planning and re-planning are contained in this process area. [PA163.N104]

The term "project plan" is used throughout the generic and specific practices in this process area to refer to the overall plan for controlling the project. [PA163.N105]

Related Process Areas

Refer to the Requirements Development process area for more information about developing requirements that define the product and product components. Product and product-component requirements and changes to those requirements serve as a basis for planning and re-planning. [PA163.R101]

Refer to the Requirements Management process area for more information about managing requirements needed for planning and re-planning. [PA163.R102]

Refer to the Risk Management process area for more information about identifying and managing risks. [PA163.R103]

Refer to the Technical Solution process area for more information about transforming requirements into product and product-component solutions. [PA163.R104]

Specific and Generic Goals

SG 1 **Establish Estimates** [PA163.IG101]

Estimates of project planning parameters are established and maintained.

SG 2 **Develop a Project Plan** [PA163.IG102]

A project plan is established and maintained as the basis for managing the project.

SG 3 **Obtain Commitment to the Plan** [PA163.IG103]

Commitments to the project plan are established and maintained.

GG 2 **Institutionalize a Managed Process** [CL103.GL101]

The process is institutionalized as a managed process.

(The following goal is not required for maturity level 2, but required for maturity level 3 and above.)

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Establish Estimates [PA163.IG101]

- SP 1.1 Estimate the Scope of the Project
- SP 1.2 Establish Estimates of Work Product and Task Attributes
- SP 1.3 Define Project Life Cycle
- SP 1.4 Determine Estimates of Effort and Cost

SG 2 Develop a Project Plan [PA163.IG102]

- SP 2.1 Establish the Budget and Schedule
- SP 2.2 Identify Project Risks
- SP 2.3 Plan for Data Management
- SP 2.4 Plan for Project Resources
- SP 2.5 Plan for Needed Knowledge and Skills
- SP 2.6 Plan Stakeholder Involvement
- SP 2.7 Establish the Project Plan

SG 3 Obtain Commitment to the Plan [PA163.IG103]

- SP 3.1 Review Plans that Affect the Project
- SP 3.2 Reconcile Work and Resource Levels
- SP 3.3 Obtain Plan Commitment

GG 2 Institutionalize a Managed Process [CL103.GL101]

- GP 2.1 (CO 1) Establish an Organizational Policy
- GP 2.2 (AB 1) Plan the Process
- GP 2.3 (AB 2) Provide Resources
- GP 2.4 (AB 3) Assign Responsibility
- GP 2.5 (AB 4) Train People
- GP 2.6 (DI 1) Manage Configurations
- GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders
- GP 2.8 (DI 3) Monitor and Control the Process
- GP 2.9 (VE 1) Objectively Evaluate Adherence
- GP 2.10 (VE 2) Review Status with Higher Level Management

(The following goal is not required and its practices are not expected for a maturity level 2 rating, but are required and expected for a maturity level 3 rating and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

- GP 3.1 Establish a Defined Process
- GP 3.2 Collect Improvement Information

Specific Practices by Goal

SG 1 Establish Estimates

Estimates of project planning parameters are established and maintained. *[PA163.IG101]*

Project planning parameters include all information needed by the project to perform the necessary planning, organizing, staffing, directing, coordinating, reporting, and budgeting. [PA163.IG101.N101]

Estimates of planning parameters should have a sound basis to provide confidence that any plans based on these estimates are capable of supporting project objectives. [PA163.IG101.N102]

Factors that are typically considered when estimating these parameters include the following: [PA163.IG101.N103]

- Project requirements, including the product requirements, the requirements imposed by the organization, the requirements imposed by the customer, and other requirements that impact the project
- Scope of the project
- Identified tasks and work products
- Technical approach
- Selected project life-cycle model (e.g., waterfall, incremental, spiral, etc.)
- Attributes of the work products and tasks (e.g., size or complexity)
- Schedule
- Models or historical data for converting the attributes of the work products and tasks into labor hours and cost
- Methodology (models, data, algorithms) used to determine needed material, skills, labor hours, and cost

Documenting the estimating rationale and supporting data is needed for stakeholders' review and commitment to the plan and for maintenance of the plan as the project progresses. [PA163.IG101.N104]

SP 1.1 Estimate the Scope of the Project

Establish a top-level work breakdown structure (WBS) to estimate the scope of the project. *[PA163.IG101.SP101]*

The WBS evolves with the project. Initially a top-level WBS can serve to structure the initial estimating. The development of a WBS divides the overall project into an interconnected set of manageable components. The WBS is typically a product-oriented structure that provides a scheme for identifying and organizing the logical units of work to be managed, which are called "work packages." The WBS provides a reference and organizational mechanism for assigning effort, schedule, and responsibility and is used as the underlying framework to plan, organize, and control the work done on the project. [PA163.IG101.SP101.N101]

Typical Work Products

1. Task descriptions [PA163.IG101.SP101.W101]
2. Work package descriptions [PA163.IG101.SP101.W102]

3. WBS [PA163.IG101.SP101.W103]

Subpractices

1. Develop a WBS based on the product architecture.
[PA163.IG101.SP101.SubP101]

   The WBS provides a scheme for organizing the project's work around the products that the work supports. The WBS should permit the identification of the following items: [PA163.IG101.SP101.SubP101.N101]

   - Identified risks and their mitigation tasks
   - Tasks for deliverables and supporting activities
   - Tasks for skill and knowledge acquisition
   - Tasks for development of needed support plans, such as configuration management, quality assurance, and verification plans
   - Tasks for integration and management of non-developmental items

2. Identify the work packages in sufficient detail to specify estimates of project tasks, responsibilities, and schedule. [PA163.IG101.SP101.SubP102]

   The top-level WBS is intended to help in gauging the project work effort in terms of tasks and organizational roles and responsibilities. The amount of detail in the WBS at this more detailed level helps in developing realistic schedules, thereby minimizing the need for management reserve. [PA163.IG101.SP101.SubP102.N101]

3. Identify work products (or components of work products) that will be externally acquired. [PA163.IG101.SP101.SubP103]

   Refer to the Supplier Agreement Management process area for more information about acquiring work products from sources external to the project. *[PA163.IG101.SP101.SubP103.R101]*

4. Identify work products that will be reused. [PA163.IG101.SP101.SubP104]

SP 1.2 Establish Estimates of Work Product and Task Attributes

Establish and maintain estimates of the attributes of the work products and tasks. *[PA163.IG101.SP102]*

Size is the primary input to many models used to estimate effort, cost, and schedule. The models may also be based on inputs such as connectivity, complexity, and structure. [PA163.IG101.SP102.N102]

Examples of types of work products for which size estimates are made include the following: [PA163.IG101.SP102.N103]

- Deliverable and nondeliverable work products
- Documents
- Operational and support software

Examples of size measures include the following: [PA163.IG101.SP102.N104]

- Number of functions
- Function points
- Source lines of code
- Number of classes and objects
- Number of requirements
- Number of interfaces
- Number of pages
- Number of inputs and outputs
- Number of technical risk items
- Volume of data

The estimates should be consistent with project requirements to determine the project's effort, cost, and schedule. A relative level of difficulty or complexity should be assigned for each size attribute. [PA163.IG101.SP102.N101]

Typical Work Products

1. Technical approach [PA163.IG101.SP102.W101]
2. Size and complexity of tasks and work products [PA163.IG101.SP102.W102]
3. Estimating models [PA163.IG101.SP102.W103]
4. Attribute estimates [PA163.IG101.SP102.W104]

Subpractices

1. Determine the technical approach for the project. [PA163.IG101.SP102.SubP101]

   The technical approach defines a top-level strategy for development of the products. It includes decisions on architectural features, such as distributed or client server; state-of-the-art or established technologies to be applied, such as robotics, composite materials, or artificial intelligence; and breadth of the functionality expected in the final products, such as safety, security, and ergonomics. [PA163.IG101.SP102.SubP101.N101]

2. Use appropriate methods to determine the attributes of the work products and tasks that will be used to estimate the resource requirements. [PA163.IG101.SP102.SubP102]

   Methods for determining size and complexity should be based on validated models or historical data. [PA163.IG101.SP102.SubP102.N101]

   The methods for determining attributes evolve as our understanding of the relationship of product characteristics to attributes increases.
   [PA163.IG101.SP102.SubP102.N102]

   Examples of current methods include the following: [PA163.IG101.SP102.SubP102.N103]

   - Number of logic gates for integrated circuit design
   - Lines of code or function points for software
   - Number/complexity of requirements for systems engineering
   - Number of square feet for standard-specified residential homes

3. Estimate the attributes of the work products and tasks.
   [PA163.IG101.SP102.SubP103]

4. Estimate, as appropriate, the labor, machinery, materials, and methods that will be required by the project. [PA163.IG101.SP102.SubP104]

SP 1.3 Define Project Life Cycle

Define the project life-cycle phases upon which to scope the planning effort. *[PA163.IG101.SP103]*

The determination of a project's life-cycle phases provides for planned periods of evaluation and decision making. These are normally defined to support logical decision points at which significant commitments are made concerning resources and technical approach. Such points provide planned events at which project course corrections and determinations of future scope and cost can be made. [PA163.IG101.SP103.N101]

For Software Engineering

The determination of project phases for software typically includes selection and refinement of a software development model to address interdependencies and appropriate sequencing of software project activities.

[PA163.IG101.SP103.N101.AMP101]

For Systems Engineering

Identify the major product phase (e.g., concept exploration, development, etc.) for the current state of the product, expected future phases, and the relationships and effects among phases. Adjust planning parameters to account for relationships and effects among phases.

[PA163.IG101.SP103.N101.AMP102]

The project life cycle consists of phases that need to be defined depending on the scope of requirements, the estimates for project resources, and the nature of the project. Larger projects may contain multiple phases, such as concept exploration, development, production, operations, and disposal. Within these phases, subphases may be needed. A development phase may include subphases such as requirements analysis, design, fabrication, integration, and verification. Depending on the strategy for development, there may be intermediate phases for the creation of prototypes, increments of capability, or spiral model cycles. [PA163.IG101.SP103.N102]

Understanding the project life cycle is crucial in determining the scope of the planning effort and the timing of the initial planning, as well as the timing and criteria (critical milestones) for re-planning. [PA163.IG101.SP103.N103]

Typical Work Products

1. Project life-cycle phases [PA163.IG101.SP103.W101]

SP 1.4 Determine Estimates of Effort and Cost

Estimate the project effort and cost for the work products and tasks based on estimation rationale. *[PA163.IG101.SP104]*

Estimates of effort and cost are generally based on the results of analysis using models or historical data applied to size, activities, and other planning parameters. Confidence in these estimates is based on the rationale for the selected model and the nature of the data. There may be occasions where the available historical data does not apply, such as where efforts are unprecedented or where the type of task does not fit available models. An effort is unprecedented (to some degree) if a similar product or component has never been built. An effort may also be unprecedented if the development group has never built such a product or component. [PA163.IG101.SP104.N101]

Unprecedented efforts are more risky, require more research to develop reasonable bases of estimate, and require more management reserve. The uniqueness of the project must be documented when using these models to ensure a common understanding of any assumptions made in the initial planning stages. [PA163.IG101.SP104.N102]

Typical Work Products

1. Estimation rationale [PA163.IG101.SP104.W101]
2. Project effort estimates [PA163.IG101.SP104.W102]
3. Project cost estimates [PA163.IG101.SP104.W104]

Subpractices

1. Collect the models or historical data that will be used to transform the attributes of the work products and tasks into estimates of the labor hours and cost. [PA163.IG101.SP104.SubP101]

   For Software Engineering

   Within the software-engineering area, many parametric models have been developed to aid in estimating cost and schedule. The use of these models as the sole source of estimation is not recommended as these models are based on historical project data that may or may not be pertinent to your project. Multiple models and/or methods may be used to ensure a high level of confidence in the estimate.
   [PA163.IG101.SP104.SubP101.AMP101]

   Historical data include the cost, effort, and schedule data from previously executed projects, plus appropriate scaling data to account for differing sizes and complexity. [PA163.IG101.SP104.SubP101.N101]

2. Include supporting infrastructure needs when estimating effort and cost. [PA163.IG101.SP104.SubP102]

   The support infrastructure includes items needed from a development and sustainment perspective for the product. [PA163.IG101.SP104.SubP102.N101]

   For Software Engineering

   Consider critical computer resources in the host environment, in the test environment, in the target environment, or in any combination of these. Computer resource estimation typically includes the following: *[PA163.IG101.SP104.SubP102.N101.AMP101]*

   - *identifying the critical computer resources for the software project and*
   - *basing estimates of critical computer resources on allocated requirements*

For Software Engineering

Examples of critical computer resources include the following:

[PA163.IG101.SP104.SubP102.N101.AMP102]

- *Memory, disk, and network capacity*
- *Processor power*
- *Communications channel capacity*
- *Workstation power*
- *Peripheral capacity*

For Software Engineering

Examples of software-engineering facilities include the following:

[PA163.IG101.SP104.SubP102.N101.AMP103]

- *Host computers, peripherals, and networks*
- *Software test computers and peripherals*
- *Target computer environment software*
- *Software-engineering environment (i.e., software tools)*

3. Estimate effort and cost using models and/or historical data.

[PA163.IG101.SP104.SubP103]

Effort and cost inputs used for estimating typically include the following:

[PA163.IG101.SP104.SubP103.N101]

- Judgmental estimates provided by an expert or group of experts (e.g., Delphi Method)
- Risks, including the extent to which the effort is unprecedented
- Critical competencies and roles needed to perform the work
- Product and product-component requirements
- Technical approach
- WBS
- Size estimates of work products and anticipated changes
- Cost of externally acquired work products
- Selected project life-cycle model and processes
- Life-cycle cost estimates
- Capability of tools provided in engineering environment
- Skill levels of managers and staff needed to perform the work
- Knowledge, skill, and training needs
- Facilities needed (e.g., office and meeting space and workstations)
- Engineering facilities needed

- Capability of manufacturing process(es)
- Travel
- Level of security required for tasks, work products, hardware, software, personnel, and work environment
- Service-level agreements for call centers and warranty work
- Direct labor and overhead

SG 2 Develop a Project Plan

A project plan is established and maintained as the basis for managing the project. *[PA163.IG102]*

A project plan is a formal, approved document used to manage and control the execution of the project. It is based on the project requirements and the established estimates. [PA163.IG102.N101]

The project plan should consider all phases of the project life cycle. Project planning should ensure that all plans affecting the project are consistent with the overall project plan. [PA163.IG102.N102]

SP 2.1 Establish the Budget and Schedule

Establish and maintain the project's budget and schedule.
[PA163.IG102.SP101]

The project's budget and schedule are based on the developed estimates and ensure that budget allocation, task complexity, and task dependencies are appropriately addressed. [PA163.IG102.SP101.N101]

Event-driven, resource-limited schedules have proven to be effective in dealing with project risk. Identifying accomplishments to be demonstrated before initiation of the event provides some flexibility in the timing of the event, a common understanding of what is expected, a better vision of the state of the project, and a more accurate status of the project's tasks. [PA163.IG102.SP101.N102]

Typical Work Products

1. Project schedules [PA163.IG102.SP101.W101]
2. Schedule dependencies [PA163.IG102.SP101.W102]
3. Project budget [PA163.IG102.SP101.W103]

Subpractices

1. Identify major milestones. [PA163.IG102.SP101.SubP101]

Milestones are often imposed to ensure completion of certain deliverables by the milestone. Milestones can be event based or calendar based. If calendar based, once milestone dates have been agreed upon, it is often very difficult to change them. [PA163.IG102.SP101.SubP101.N101]

2. Identify schedule assumptions. [PA163.IG102.SP101.SubP102]

When schedules are initially developed, it is common to make assumptions about the duration of certain activities. These assumptions are frequently made on items for which little if any estimation data is available. Identifying these assumptions provides insight into the level of confidence (uncertainties) in the overall schedule. [PA163.IG102.SP101.SubP102.N101]

3. Identify constraints. [PA163.IG102.SP101.SubP103]

Factors that limit the flexibility of management options need to be identified as early as possible. The examination of the attributes of the work products and tasks will often surface these issues. Such attributes can include task duration, resources, inputs, and outputs. [PA163.IG102.SP101.SubP103.N101]

4. Identify task dependencies. [PA163.IG102.SP101.SubP104]

Typically, the tasks for a project can be accomplished in some ordered sequence that will minimize the duration of the project. This involves the identification of predecessor and successor tasks to determine the optimal ordering. [PA163.IG102.SP101.SubP104.N101]

Examples of tools that can help determine an optimal ordering of task activities include the following: [PA163.IG102.SP101.SubP104.N102]

- Critical Path Method (CPM)
- Program Evaluation and Review Technique (PERT)
- Resource-limited scheduling

5. Define the budget and schedule. [PA163.IG102.SP101.SubP105]

Establishing and maintaining the project's budget and schedule typically includes the following: [PA163.IG102.SP101.SubP105.N101]

- Defining the committed or expected availability of resources and facilities
- Determining time phasing of activities
- Determining a breakout of subordinate schedules
- Defining the dependencies between the activities (predecessor or successor relationships)
- Defining the schedule activities and milestones to support accuracy in progress measurement
- Identifying milestones for delivery of products to the customer
- Defining activities of appropriate duration

- Defining milestones of appropriate time separation
- Defining a management reserve based on the confidence level in meeting the schedule and budget
- Using appropriate historical data to verify the schedule
- Defining incremental funding requirements
- Documenting project assumptions and rationale

6. Establish corrective action criteria. [PA163.IG102.SP101.SubP106]

   Criteria are established for determining what constitutes a significant deviation from the project plan. A basis for gauging issues and problems is necessary to determine when a corrective action should be taken. The corrective actions may require re-planning, which may include revising the original plan, establishing new agreements, or including mitigation activities within the current plan.
   [PA163.IG102.SP101.SubP106.N101]

SP 2.2 Identify Project Risks

Identify and analyze project risks. *[PA163.IG102.SP103]*

Refer to the Risk Management process area for more information about risk management activities. *[PA163.IG102.SP103.R101]*

Refer to the Monitor Project Risks specific practice in the Project Monitoring and Control process area for more information about risk monitoring activities. *[PA163.IG102.SP103.R102]*

Risks are identified or discovered and analyzed to support project planning. This specific practice should be extended to all the plans that affect the project to ensure that the appropriate interfacing is taking place between all relevant stakeholders on identified risks. Project planning risk identification and analysis typically include the following:
[PA163.IG102.SP103.N101]

- Identifying risks
- Analyzing the risks to determine the impact, probability of occurrence, and time frame in which problems are likely to occur
- Prioritizing risks

Typical Work Products

1. Identified risks [PA163.IG102.SP103.W101]
2. Risk impacts and probability of occurrence [PA163.IG102.SP103.W102]
3. Risk priorities [PA163.IG102.SP103.W103]

Subpractices

1. Identify risks. [PA163.IG102.SP103.SubP101]

The identification of risks involves the identification of potential issues, hazards, threats, vulnerabilities, etc. that could negatively affect work efforts and plans. Risks must be identified and described in an understandable way before they can be analyzed. When identifying risks, it is good to use a standard method for defining risks. Risk identification and analysis tools may be used to help identify possible problems. [PA163.IG102.SP103.SubP101.N101]

Examples of risk identification and analysis tools include the following: [PA163.IG102.SP103.SubP101.N102]

- Risk taxonomies
- Risk assessments
- Checklists
- Structured interviews
- Brainstorming
- Performance models
- Cost models
- Network analysis
- Quality factor analysis

2. Document the risks. [PA163.IG102.SP103.SubP102]
3. Review and obtain agreement with relevant stakeholders on the completeness and correctness of the documented risks. [PA163.IG102.SP103.SubP103]
4. Revise the risks as appropriate. [PA163.IG102.SP103.SubP104]

Examples of when identified risks may need to be revised include the following: [PA163.IG102.SP103.SubP104.N101]

- When new risk is identified
- When risks become problems
- When risks are retired
- When project circumstances change significantly

SP 2.3 Plan for Data Management

Plan for the management of project data. *[PA163.IG102.SP102]*

For Integrated Product and Process Development

When integrated teams are formed, project data includes data developed and used solely within a particular team as well as data applicable across integrated team boundaries if there are multiple integrated teams. *[PA163.IG102.SP102.AMP101]*

Data are the various forms of documentation required to support a program in all of its areas (e.g., administration, engineering, configuration management, financial, logistics, quality, safety, manufacturing, and procurement). The data may take any form (e.g., reports, manuals, notebooks, charts, drawings, specifications, files, or correspondence). The data may exist in any medium (e.g., printed or drawn on various materials, photographs, electronic, or multimedia). Data may be deliverable (e.g., items identified by a program's contract data requirements) or data may be nondeliverable (e.g., informal data, trade studies and analyses, internal meeting minutes, internal design review documentation, lessons learned, and action items). Distribution may take many forms, including electronic transmission. [PA163.IG102.SP102.N101]

The data requirements for the project should be established for both the data items to be created and their content and form, based on a common or standard set of data requirements. Uniform content and format requirements for data items facilitate understanding of data content and help with consistent management of the data resources. [PA163.IG102.SP102.N102]

The reason for collecting each document should be clear. This task includes the analysis and verification of project deliverables and nondeliverables, contract and noncontract data requirements, and customer-supplied data. Often, data is collected with no clear understanding of how it will be used. Data is costly and should be collected only when needed. [PA163.IG102.SP102.N103]

Typical Work Products

1. Data management plan [PA163.IG102.SP102.W101]
2. Master list of managed data [PA163.IG102.SP102.W102]
3. Data content and format description [PA163.IG102.SP102.W103]
4. Data requirements lists for acquirers and for suppliers [PA163.IG102.SP102.W104]
5. Privacy requirements [PA163.IG102.SP102.W105]
6. Security requirements [PA163.IG102.SP102.W106]
7. Security procedures [PA163.IG102.SP102.W107]
8. Mechanism for data retrieval, reproduction, and distribution [PA163.IG102.SP102.W108]
9. Schedule for collection of project data [PA163.IG102.SP102.W109]
10. Listing of project data to be collected [PA163.IG102.SP102.W110]

Subpractices

1. Establish requirements and procedures to ensure privacy and security of the data. [PA163.IG102.SP102.SubP101]

   Not everyone will have the need or clearance necessary to access the project data. Procedures must be established to identify who has access to what data as well as when they have access to the data. [PA163.IG102.SP102.SubP101.N101]

2. Establish a mechanism to archive data and to access archived data. [PA163.IG102.SP102.SubP102]

   Accessed information should be in an understandable form (e.g., electronic or computer output from a database) or represented as originally generated.
   [PA163.IG102.SP102.SubP102.N101]

3. Determine the project data to be identified, collected, and distributed. [PA163.IG102.SP102.SubP103]

SP 2.4 Plan for Project Resources

Plan for necessary resources to perform the project. *[PA163.IG102.SP104]*

For Integrated Product and Process Development

When integrated teams are formed, planning for project resources has to consider staffing of the integrated teams.
[PA163.IG102.SP104.AMP101]

Defining project resources (labor, machinery/equipment, materials, and methods) and quantities needed to perform project activities builds on the initial estimates and provides additional information that can be applied to expand the WBS used to manage the project.
[PA163.IG102.SP104.N101]

The top-level WBS developed earlier as an estimation mechanism is typically expanded by decomposing these top levels into work packages that represent singular work units that can be separately assigned, performed, and tracked. This subdivision is done to distribute management responsibility and provide better management control. Each work package or work product in the WBS should be assigned a unique identifier (e.g., number) to permit tracking. A WBS may be based on requirements, activities, work products, or a combination of these items. A dictionary that describes the work for each work package in the WBS should accompany the work breakdown structure.
[PA163.IG102.SP104.N102]

Typical Work Products

1. WBS work packages [PA163.IG102.SP104.W101]
2. WBS task dictionary [PA163.IG102.SP104.W102]

3. Staffing requirements based on project size and scope [PA163.IG102.SP104.W103]
4. Critical facilities/equipment list [PA163.IG102.SP104.W104]
5. Process/workflow definitions and diagrams [PA163.IG102.SP104.W105]
6. Program administration requirements list [PA163.IG102.SP104.W106]

Subpractices

1. Determine process requirements. [PA163.IG102.SP104.SubP101]

   The processes used to manage a project must be identified, defined, and coordinated with all the relevant stakeholders to ensure efficient operations during project execution. [PA163.IG102.SP104.SubP101.N101]

2. Determine staffing requirements. [PA163.IG102.SP104.SubP102]

   The staffing of a project depends on the decomposition of the project requirements into tasks, roles, and responsibilities for accomplishing the project requirements as laid out within the work packages of the WBS. [PA163.IG102.SP104.SubP102.N101]

   Staffing requirements must consider the knowledge and skills required for each of the identified positions, as defined in the Plan for Needed Knowledge and Skills specific practice. [PA163.IG102.SP104.SubP102.N102]

3. Determine facilities, equipment, and component requirements. [PA163.IG102.SP104.SubP103]

   Most projects are unique in some sense and require some set of unique assets to accomplish the objectives of the project. The determination and acquisition of these assets in a timely manner are crucial to project success. [PA163.IG102.SP104.SubP103.N101]

   Lead-time items need to be identified early to determine how they will be addressed. Even when the required assets are not unique, compiling a list of all of the facilities, equipment, and parts (e.g., number of computers for the personnel working on the project, software applications, office space, etc.) provides insight into aspects of the scope of an effort that are often overlooked. [PA163.IG102.SP104.SubP103.N102]

SP 2.5 Plan for Needed Knowledge and Skills

Plan for knowledge and skills needed to perform the project. *[PA163.IG102.SP105]*

Refer to the Organizational Training process area for more information about knowledge and skills information to be incorporated into the project plan. *[PA163.IG102.SP105.R101]*

Knowledge delivery to projects involves both training of project personnel and acquisition of knowledge from outside sources. [PA163.IG102.SP105.N101]

Staffing requirements are dependent on the knowledge and skills available to support the execution of the project. [PA163.IG102.SP105.N102]

Typical Work Products

1. Inventory of skill needs [PA163.IG102.SP105.W101]
2. Staffing and new hire plans [PA163.IG102.SP105.W103]
3. Databases (e.g., skills and training) [PA163.IG102.SP105.W104]

Subpractices

1. Identify the knowledge and skills needed to perform the project. [PA163.IG102.SP105.SubP101]
2. Assess the knowledge and skills available. [PA163.IG102.SP105.SubP102]
3. Select mechanisms for providing needed knowledge and skills. [PA163.IG102.SP105.SubP103]

Example mechanisms include the following: [PA163.IG102.SP105.SubP103.N101]

- In-house training (both organizational and project)
- External training
- Staffing and new hires
- External skill acquisition

The choice of in-house training or external outsourcing for the needed knowledge and skills is determined by the availability of training expertise, the project's schedule, and business objectives. [PA163.IG102.SP105.SubP103.N102]

4. Incorporate selected mechanisms in the project plan. [PA163.IG102.SP105.SubP104]

SP 2.6 Plan Stakeholder Involvement

Plan the involvement of identified stakeholders. *[PA163.IG102.SP106]*

For Integrated Product and Process Development

When integrated teams are formed, stakeholder involvement needs to be planned down to the integrated team level. *[PA163.IG102.SP106.AMP101]*

Stakeholders are identified from all phases of the project life cycle by identifying the type of people and functions needing representation in the project and describing their relevance and the degree of interaction for specific project activities. A two-dimensional matrix with stakeholders along one axis and project activities along the other axis is a convenient format for accomplishing this identification. Relevance of the stakeholder to the activity in a particular project phase and the amount of interaction expected would be shown at the intersection of the project phase activity axis and the stakeholder axis.

[PA163.IG102.SP106.N101]

For the inputs of stakeholders to be useful, careful selection of relevant stakeholders is necessary. For each major activity, identify the stakeholders that are affected by the activity and those who have expertise that is needed to conduct the activity. This list of relevant stakeholders will probably change as the project moves through the phases of the project life cycle. It is important, however, to ensure that relevant stakeholders in the later phases of the life cycle have early input to requirements and design decisions that affect them.

[PA163.IG102.SP106.N102]

Examples of the type of material that should be included in a plan for stakeholder interaction include the following: [PA163.IG102.SP106.N103]

- List of all relevant stakeholders
- Rationale for stakeholder involvement
- Roles and responsibilities of the relevant stakeholders with respect to the project, by project life-cycle phase
- Relationships between stakeholders
- Relative importance of the stakeholder to success of the project, by project life-cycle phase
- Resources (e.g., training, materials, time, funding) needed to ensure stakeholder interaction
- Schedule for phasing of stakeholder interaction

Conduct of this specific practice relies on shared or exchanged information with the previous Plan for Needed Knowledge and Skills specific practice. [PA163.IG102.SP106.N104]

Typical Work Products

1. Stakeholder involvement plan [PA163.IG102.SP106.W101]

SP 2.7 Establish the Project Plan

Establish and maintain the overall project plan content.

[PA163.IG102.SP107]

For Systems Engineering

Systems-engineering planning details the work activities and work products of the integrated technical effort across the project. [PA163.IG102.SP107.AMP101]

For Systems Engineering

Examples of plans that have been used in the U.S. Department of Defense community include the following: [PA163.IG102.SP107.AMP103]

- *Integrated Master Plan – an event-driven plan that documents significant accomplishments with pass/fail criteria for both business and technical elements of the project and ties each accomplishment to a key program event.*
- *Integrated Master Schedule – an integrated and networked multi-layered schedule of program tasks required to complete the work effort documented in a related Integrated Master Plan.*
- *Systems-Engineering Management Plan – a plan that details the integrated technical effort across the project.*
- *Systems-Engineering Master Schedule – an event-based schedule that contains a compilation of key technical accomplishments, each with measurable criteria, requiring successful completion to pass identified events.*
- *Systems-Engineering Detailed Schedule – a detailed, time-dependent, task-oriented schedule that associates specific dates and milestones with the Systems-Engineering Master Schedule.*

For Software Engineering

For software, the planning document is often referred to as one of the following: [PA163.IG102.SP107.AMP102]

- *Software development plan*
- *Software project plan*
- *Software plan*

A documented plan that addresses all relevant planning items is necessary to achieve the mutual understanding, commitment, and performance of individuals, groups, and organizations that must execute or support the plans. The plan generated for the project defines all aspects of the effort, tying together in a logical manner: project life-cycle considerations; technical and management tasks; budgets and schedules; milestones; data management, risk identification, resource and skill requirements; and stakeholder identification and interaction. Infrastructure descriptions include responsibility and authority relationships for project staff, management, and support organizations. [PA163.IG102.SP107.N101]

Typical Work Products

1. Overall project plan [PA163.IG102.SP107.W101]

SG 3 Obtain Commitment to the Plan

Commitments to the project plan are established and maintained. *[PA163.IG103]*

To be effective, plans require commitment by those responsible for implementing and supporting the plan. [PA163.IG103.N101]

SP 3.1 Review Plans that Affect the Project

Review all plans that affect the project to understand project commitments. *[PA163.IG103.SP103]*

For Integrated Product and Process Development

When integrated teams are formed, their integrated work plans are among the plans to review. *[PA163.IG103.SP103.AMP101]*

Plans developed within other process areas will typically contain information similar to that called for in the overall project plan. These plans may provide additional detailed guidance and should be compatible with and support the overall project plan to indicate who has the authority, responsibility, accountability, and control. All plans that affect the project should be reviewed to ensure a common understanding of the scope, objectives, roles, and relationships that are required for the project to be successful. Many of these plans are described by the Plan the Process generic practice in each of the process areas. [PA163.IG103.SP103.N101]

Typical Work Products

1. Record of the reviews of plans that affect the project
   [PA163.IG103.SP103.W101]

SP 3.2 Reconcile Work and Resource Levels

Reconcile the project plan to reflect available and estimated resources. *[PA163.IG103.SP101]*

For Integrated Product and Process Development

When integrated teams are formed, special attention needs to be paid to resource commitments in circumstances of distributed integrated teams and when people are on multiple integrated teams in one or many projects. *[PA163.IG103.SP101.AMP101]*

To obtain commitment from relevant stakeholders, it is important to reconcile any differences between the estimates and the available resources. Reconciliation is typically accomplished by lowering or deferring technical performance requirements, negotiating more resources, finding ways to increase productivity, outsourcing, adjusting the staff skill mix, or revising all plans that affect the project or schedules. [PA163.IG103.SP101.N101]

Typical Work Products

1. Revised methods and corresponding estimating parameters (e.g., better tools, use of off-the-shelf components) [PA163.IG103.SP101.W101]
2. Renegotiated budgets [PA163.IG103.SP101.W102]
3. Revised schedules [PA163.IG103.SP101.W103]
4. Revised requirements list [PA163.IG103.SP101.W104]
5. Renegotiated stakeholder agreements [PA163.IG103.SP101.W105]

SP 3.3 Obtain Plan Commitment

Obtain commitment from relevant stakeholders responsible for performing and supporting plan execution. *[PA163.IG103.SP102]*

For Integrated Product and Process Development

When integrated teams are formed, the integrated team plans will need buy-in from the team members, the interfacing teams, the project, and the process owners of the standard processes that team has selected for tailored application.

[PA163.IG103.SP102.AMP101]

Obtaining commitment involves interaction among all relevant stakeholders both internal and external to the project. The individual or group making a commitment should have confidence that the work can be performed within cost, schedule, and performance constraints. Often, a provisional commitment is adequate to allow the effort to begin and to permit research to be performed to increase confidence to the appropriate level needed to obtain a full commitment. [PA163.IG103.SP102.N101]

Typical Work Products

1. Documented requests for commitments [PA163.IG103.SP102.W101]
2. Documented commitments [PA163.IG103.SP102.W102]

Subpractices

1. Identify needed support and negotiate commitments with relevant stakeholders. [PA163.IG103.SP102.SubP101]

The WBS can be used as a checklist for ensuring that commitments are obtained for all tasks. [PA163.IG103.SP102.SubP101.N101]

The plan for stakeholder interaction should identify all parties from whom commitment should be obtained. [PA163.IG103.SP102.SubP101.N102]

2. Document all organizational commitments, both full and provisional, ensuring appropriate level of signatories. [PA163.IG103.SP102.SubP102]

   Commitments must be documented to ensure a consistent mutual understanding as well as for tracking and maintenance. Provisional commitments should be accompanied by a description of the risks associated with the relationship. [PA163.IG103.SP102.SubP102.N101]

3. Review internal commitments with senior management as appropriate. [PA163.IG103.SP102.SubP103]

4. Review external commitments with senior management as appropriate. [PA163.IG103.SP102.SubP104]

   Management may have the necessary insight and authority to reduce risks associated with external commitments. [PA163.IG103.SP102.SubP104.N101]

5. Identify commitments on interfaces between elements in the project, and with other projects and organizational units, so they can be monitored. [PA163.IG103.SP102.SubP105]

   Well-defined interface specifications form the basis for commitments. [PA163.IG103.SP102.SubP105.N101]

GG 2 Institutionalize a Managed Process [CL103.GL101]

The process is institutionalized as a managed process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the project planning process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for estimating the planning parameters, making internal and external commitments, and developing the plan for managing the project. [PA163.EL101]

GP 2.2 (AB 1) Plan the Process

Establish and maintain the plan for performing the project planning process. *[GP104]*

Elaboration:

This plan for performing the project planning process differs from the project plan described in specific practices in this process area. The plan called for in this generic practice would address the comprehensive planning for all of the specific practices in this process area, from estimating the scope of the project all the way to obtaining commitment for the project plan. In other words, this generic practice calls for one to "plan the plan." In contrast, the project plan called for in the specific practices would address planning for the project effort itself in a comprehensive manner. [PA163.EL103]

GP 2.3 (AB 2) Provide Resources

Provide adequate resources for performing the project planning process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Special expertise, equipment, and facilities in project planning may be required. Special expertise in project planning may include the following: [PA163.EL104]

- Experienced estimators
- Schedulers
- Technical experts in applicable areas (e.g., product domain and technology)

Examples of other resources provided include the following tools: [PA163.EL106]

- Spreadsheet programs
- Estimating models
- Project planning and scheduling packages

GP 2.4 (AB 3) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the project planning process. *[GP106]*

GP 2.5 (AB 4) Train People

Train the people performing or supporting the project planning process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA163.EL108]

- Estimating
- Budgeting
- Negotiating
- Risk identification and analysis
- Data management
- Planning
- Scheduling

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the project planning process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA163.EL110]

- Work breakdown structure
- Project plan
- Data management plan
- Stakeholder involvement plan

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the project planning process as planned. *[GP124]*

Elaboration:

This generic practice is different from developing the plan for stakeholder involvement for the project itself, which is covered in a specific practice of this process area. [PA163.EL111]

Select relevant stakeholders from senior managers, project managers, project functional managers (e.g., systems engineering, software engineering, other disciplines), software engineers, systems engineers, manufacturing engineers, logisticians, suppliers, customers, and others who may be affected by, or may affect, the project. [PA163.EL118]

Examples of activities for stakeholder involvement include the following: [PA163.EL119]

- Establishing estimates
- Reviewing and resolving issues on the completeness and correctness of the project risks
- Reviewing data management plans
- Establishing project plans
- Reviewing project plans and resolving issues on work and resource issues

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the project planning process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA163.EL113]

- Number of revisions to the plan
- Cost, schedule, and effort variance per plan revision

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the project planning process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA163.EL115]

- Establishing estimates
- Developing a project plan
- Obtaining commitments to the project plan

Examples of work products reviewed include the following: [PA163.EL117]

- WBS
- Project plan
- Data management plan
- Stakeholder involvement plan

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the project planning process with higher level management and resolve issues. *[GP112]*

(The following goal is not required and its practices are not expected for a maturity level 2 rating, but are required for a maturity level 3 rating and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

GP 3.1 Establish a Defined Process

Establish and maintain the description of a defined project planning process. *[GP114]*

GP 3.2 Collect Improvement Information

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

[GP117]

PROJECT MONITORING AND CONTROL

Maturity Level 2

Purpose

The purpose of Project Monitoring and Control is to provide an understanding of the project's progress so that appropriate corrective actions can be taken when the project's performance deviates significantly from the plan. [PA162]

Introductory Notes

A project's documented plan is the basis for monitoring activities, communicating status, and taking corrective action. Progress is primarily determined by comparing actual work product and task attributes, effort, cost, and schedule to the plan at prescribed milestones or control levels within the project schedule or work breakdown structure. Appropriate visibility enables timely corrective action to be taken when performance deviates significantly from the plan. A deviation is significant if, when left unresolved, it precludes the project from meeting its objectives. [PA162.N101]

The term "project plan" is used throughout these practices to refer to the overall plan for controlling the project. [PA162.N102]

When actual status deviates significantly from the expected values, corrective actions are taken as appropriate. These actions may require re-planning, which may include revising the original plan, establishing new agreements, or including additional mitigation activities within the current plan. [PA162.N103]

Related Process Areas

Refer to the Project Planning process area for more information about the project plan, including how it specifies the appropriate level of project monitoring, the measures used to monitor progress, and known risks. [PA162.R101]

Refer to the Measurement and Analysis process area for information about the process of measuring, analyzing, and recording information. [PA162.R102]

Specific and Generic Goals

SG 1 **Monitor Project Against Plan** [PA162.IG101]

Actual performance and progress of the project are monitored against the project plan.

SG 2 **Manage Corrective Action to Closure** [PA162.IG102]

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

GG 2 **Institutionalize a Managed Process** [CL103.GL101]

The process is institutionalized as a managed process.

(The following goal is not required for maturity level 2, but required for maturity level 3 and above.)

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Monitor Project Against Plan [PA162.IG101]

- SP 1.1 Monitor Project Planning Parameters
- SP 1.2 Monitor Commitments
- SP 1.3 Monitor Project Risks
- SP 1.4 Monitor Data Management
- SP 1.5 Monitor Stakeholder Involvement
- SP 1.6 Conduct Progress Reviews
- SP 1.7 Conduct Milestone Reviews

SG 2 Manage Corrective Action to Closure [PA162.IG102]

- SP 2.1 Analyze Issues
- SP 2.2 Take Corrective Action
- SP 2.3 Manage Corrective Action

GG 2 Institutionalize a Managed Process [CL103.GL101]

- GP 2.1 (CO 1) Establish an Organizational Policy
- GP 2.2 (AB 1) Plan the Process
- GP 2.3 (AB 2) Provide Resources
- GP 2.4 (AB 3) Assign Responsibility
- GP 2.5 (AB 4) Train People
- GP 2.6 (DI 1) Manage Configurations
- GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders
- GP 2.8 (DI 3) Monitor and Control the Process

GP 2.9 (VE 1) Objectively Evaluate Adherence
GP 2.10 (VE 2) Review Status with Higher Level Management

(The following goal is not required and its practices are not expected for a maturity level 2 rating, but are required and expected for a maturity level 3 rating and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]
GP 3.1 Establish a Defined Process
GP 3.2 Collect Improvement Information

Specific Practices by Goal

SG 1 Monitor Project Against Plan

Actual performance and progress of the project are monitored against the project plan. *[PA162.IG101]*

SP 1.1 Monitor Project Planning Parameters

Monitor the actual values of the project planning parameters against the project plan. *[PA162.IG101.SP101]*

Project planning parameters constitute typical indicators of project progress and performance and include attributes of work products and tasks, cost, effort, and schedule. Attributes of the work products and tasks include such items as size, complexity, weight, form, fit, or function. [PA162.IG101.SP101.N101]

Monitoring typically involves measuring the actual values of project planning parameters, comparing actual values to the estimates in the plan, and identifying significant deviations. Recording actual values of the project planning parameters includes recording associated contextual information to help understand the measures. An analysis of the impact that significant deviations have on determining what corrective actions to take is handled in the second specific goal and its specific practices in this process area. [PA162.IG101.SP101.N102]

Typical Work Products

1. Records of project performance [PA162.IG101.SP101.W101]
2. Records of significant deviations [PA162.IG101.SP101.W102]

Subpractices

1. Monitor progress against the schedule. [PA162.IG101.SP101.SubP101]

   Progress monitoring typically includes the following: [PA162.IG101.SP101.SubP101.N101]

   - Periodically measuring the actual completion of activities and milestones

- Comparing actual completion of activities and milestones against the schedule documented in the project plan
- Identifying significant deviations from the schedule estimates in the project plan

2. Monitor the project's cost and expended effort. [PA162.IG101.SP101.SubP102]

   Effort and cost monitoring typically includes the following: [PA162.IG101.SP101.SubP102.N101]

   - Periodically measuring the actual effort and cost expended and staff assigned
   - Comparing actual effort, costs, staffing, and training to the estimates and budgets documented in the project plan
   - Identifying significant deviations from the budgets in the project plan

3. Monitor the attributes of the work products and tasks. [PA162.IG101.SP101.SubP103]

   Refer to the Project Planning process area for information about the attributes of work products and tasks. *[PA162.IG101.SP101.SubP103.R101]*

   Monitoring the attributes of the work products and tasks typically includes the following: [PA162.IG101.SP101.SubP103.N101]

   - Periodically measuring the actual attributes of the work products and tasks, such as size or complexity (and the changes to the attributes)
   - Comparing the actual attributes of the work products and tasks (and the changes to the attributes) to the estimates documented in the project plan
   - Identifying significant deviations from the estimates in the project plan

4. Monitor resources provided and used. [PA162.IG101.SP101.SubP104]

   Refer to the Project Planning process area for information about planned resources. *[PA162.IG101.SP101.SubP104.R101]*

   For Software Engineering

   Examples of software-engineering resources include the following: *[PA162.IG101.SP101.SubP104.AMP101]*

   - *Host computers and peripherals*
   - *Networks*
   - *Software test computers and peripherals*
   - *Target computer environment software*
   - *Software-engineering environment (e.g., software tools)*

Examples of resources include: [PA162.IG101.SP101.SubP104.N101]

- Physical facilities
- Computers, peripherals, and software used in design, manufacturing, testing and operation
- Networks
- Security environment
- Project staff
- Processes

5. Monitor the knowledge and skills of project personnel.
[PA162.IG101.SP101.SubP105]

Refer to the Project Planning process area for information about planning for knowledge and skills needed to perform the project.
[PA162.IG101.SP101.SubP105.R101]

Monitoring the knowledge and skills of the project personnel typically includes the following: [PA162.IG101.SP101.SubP105.N101]

- Periodically measuring the acquisition of knowledge and skills by project personnel
- Comparing the actual training obtained to that documented in the project plan
- Identifying significant deviations from the estimates in the project plan

6. Document the significant deviations in the project planning parameters. [PA162.IG101.SP101.SubP106]

SP 1.2 Monitor Commitments

Monitor commitments against those identified in the project plan.
[PA162.IG101.SP102]

Typical Work Products

1. Records of commitment reviews [PA162.IG101.SP102.W101]

Subpractices

1. Regularly review commitments (both external and internal).
[PA162.IG101.SP102.SubP101]

2. Identify commitments that have not been satisfied or which are at significant risk of not being satisfied. [PA162.IG101.SP102.SubP102]

3. Document the results of the commitment reviews.
[PA162.IG101.SP102.SubP103]

SP 1.3 Monitor Project Risks

Monitor risks against those identified in the project plan.

[PA162.IG101.SP103]

Refer to the Project Planning process area for more information about identifying project risks. *[PA162.IG101.SP103.R101]*

Refer to the Risk Management process area for more information about risk management activities. *[PA162.IG101.SP103.R102]*

Typical Work Products

1. Records of project risk monitoring [PA162.IG101.SP103.W101]

Subpractices

1. Periodically review the documentation of the risks in the context of the project's current status and circumstances. [PA162.IG101.SP103.SubP101]
2. Revise the documentation of the risks, as additional information becomes available, to incorporate changes. [PA162.IG101.SP103.SubP102]
3. Communicate risk status to relevant stakeholders.
   [PA162.IG101.SP103.SubP103]

Examples of risk status include the following: [PA162.IG101.SP103.SubP103.N101]

- A change in the probability that the risk occurs
- A change in risk priority

SP 1.4 Monitor Data Management

Monitor the management of project data against the project plan.

[PA162.IG101.SP106]

Refer to the Plan for Data Management specific practice in the Project Planning process area for more information about identifying the types of data that should be managed and how to plan for their management.

[PA162.IG101.SP106.R101]

Once the plans for the management of project data are made, the management of that data must be monitored to ensure that those plans are accomplished. [PA162.IG101.SP106.N101]

Typical Work Products

1. Records of data management [PA162.IG101.SP106.W101]

Subpractices

1. Periodically review data management activities against their description in the project plan. [PA162.IG101.SP106.SubP101]

2. Identify and document significant issues and their impacts.
[PA162.IG101.SP106.SubP102]

3. Document the results of data management activity reviews.
[PA162.IG101.SP106.SubP103]

SP 1.5 Monitor Stakeholder Involvement

Monitor stakeholder involvement against the project plan. *[PA162.IG101.SP107]*

Refer to the Plan Stakeholder Involvement specific practice in the Project Planning process area for more information on identifying relevant stakeholders and planning the appropriate involvement with them. *[PA162.IG101.SP107.R101]*

Once the stakeholders are identified and the extent of their involvement within the project is specified in project planning, that involvement must be monitored to ensure that the appropriate interactions are occurring.
[PA162.IG101.SP107.N101]

Typical Work Products

1. Records of stakeholder involvement [PA162.IG101.SP107.W101]

Subpractices

1. Periodically review the status of stakeholder involvement.
[PA162.IG101.SP107.SubP101]

2. Identify and document significant issues and their impacts.
[PA162.IG101.SP107.SubP102]

3. Document the results of the stakeholder involvement status reviews. [PA162.IG101.SP107.SubP103]

SP 1.6 Conduct Progress Reviews

Periodically review the project's progress, performance, and issues. *[PA162.IG101.SP104]*

Progress reviews are reviews on the project to keep stakeholders informed. These project reviews can be informal reviews and may not be specified explicitly in the project plans. [PA162.IG101.SP104.N101]

Examples of these reviews include the following: [PA162.IG101.SP104.N102]

- Reviews with staff
- Reviews with project engineers and support
- Reviews with management

Typical Work Products

1. Documented project review results [PA162.IG101.SP104.W101]

Subpractices

1. Regularly communicate status on assigned activities and work products to relevant stakeholders. [PA162.IG101.SP104.SubP101]

   Managers, staff members, customers, end users, suppliers, and other relevant stakeholders within the organization are included in the reviews as appropriate. [PA162.IG101.SP104.SubP101.N101]

2. Review the results of collecting and analyzing measures for controlling the project. [PA162.IG101.SP104.SubP102]

   Refer to the Measurement and Analysis process area for more information about the process for measuring and analyzing project performance data. *[PA162.IG101.SP104.SubP102.R101]*

3. Identify and document significant issues and deviations from the plan. [PA162.IG101.SP104.SubP103]

4. Document change requests and problems identified in any of the work products and processes. [PA162.IG101.SP104.SubP104]

   Refer to the Configuration Management process area for more information about how changes are managed. *[PA162.IG101.SP104.SubP104.R101]*

5. Document the results of the reviews. [PA162.IG101.SP104.SubP105]

6. Track change requests and problem reports to closure. [PA162.IG101.SP104.SubP106]

SP 1.7 Conduct Milestone Reviews

Review the accomplishments and results of the project at selected project milestones. *[PA162.IG101.SP105]*

Refer to the Project Planning process area for more information about milestone planning. *[PA162.IG101.SP105.R101]*

Milestone reviews are planned during project planning and are typically formal reviews. [PA162.IG101.SP105.N101]

Typical Work Products

1. Documented milestone review results [PA162.IG101.SP105.W101]

Subpractices

1. Conduct reviews at meaningful points in the project's schedule, such as the completion of selected stages, with relevant stakeholders. [PA162.IG101.SP105.SubP101]

   Managers, staff members, customers, end users, suppliers, and other relevant stakeholders within the organization are included in the milestone reviews as appropriate. [PA162.IG101.SP105.SubP101.N101]

2. Review the commitments, plan, status, and risks of the project. [PA162.IG101.SP105.SubP102]

3. Identify and document significant issues and their impacts. [PA162.IG101.SP105.SubP103]

4. Document the results of the review, action items, and decisions. [PA162.IG101.SP105.SubP104]

5. Track action items to closure. [PA162.IG101.SP105.SubP105]

SG 2 Manage Corrective Action to Closure

Corrective actions are managed to closure when the project's performance or results deviate significantly from the plan. *[PA162.IG102]*

SP 2.1 Analyze Issues

Collect and analyze the issues and determine the corrective actions necessary to address the issues. *[PA162.IG102.SP101]*

Typical Work Products

1. List of issues needing corrective actions [PA162.IG102.SP101.W101]

Subpractices

1. Gather issues for analysis. [PA162.IG102.SP101.SubP101]

   Issues are collected from reviews and the execution of other processes. [PA162.IG102.SP101.SubP101.N101]

Examples of issues to be gathered include: [PA162.IG102.SP101.SubP101.N102]

- Issues discovered through performing verification and validation activities
- Significant deviations in the project planning parameters from the estimates in the project plan
- Commitments (either internal or external) that have not been satisfied
- Significant changes in risk status
- Data access, collection, privacy, or security issues
- Stakeholder representation or involvement issues

2. Analyze issues to determine need for corrective action. [PA162.IG102.SP101.SubP102]

Refer to the Project Planning process area for information about corrective action criteria. *[PA162.IG102.SP101.SubP102.R101]*

Corrective action is required when the issue, if left unresolved, may prevent the project from meeting its objectives. [PA162.IG102.SP101.SubP102.N101]

SP 2.2 Take Corrective Action

Take corrective action on identified issues. *[PA162.IG102.SP102]*

Typical Work Products

1. Corrective action plan [PA162.IG102.SP102.W101]

Subpractices

1. Determine and document the appropriate actions needed to address the identified issues. [PA162.IG102.SP102.SubP101]

Refer to the Project Planning process area for more information about the project plan when re-planning is needed.
[PA162.IG102.SP102.SubP101.R101]

Examples of potential actions include the following: [PA162.IG102.SP102.SubP101.N101]

- Modifying the statement of work
- Modifying requirements
- Revising estimates and plans
- Renegotiating commitments
- Adding resources
- Changing processes
- Revising project risks

2. Review and get agreement with relevant stakeholders on the actions to be taken. [PA162.IG102.SP102.SubP102]

3. Negotiate changes to internal and external commitments. [PA162.IG102.SP102.SubP103]

SP 2.3 Manage Corrective Action

Manage corrective actions to closure. *[PA162.IG102.SP103]*

Typical Work Products

1. Corrective action results [PA162.IG102.SP103.W101]

Subpractices

1. Monitor corrective actions for completion. [PA162.IG102.SP103.SubP101]

2. Analyze results of corrective actions to determine the effectiveness of the corrective actions. [PA162.IG102.SP103.SubP102]

3. Determine and document appropriate actions to correct deviations from planned results for corrective actions. [PA162.IG102.SP103.SubP103]

   Lessons learned as a result of taking corrective action can be inputs to planning and risk management processes. [PA162.IG102.SP103.SubP103.N101]

GG 2 Institutionalize a Managed Process [CL103.GL101]

The process is institutionalized as a managed process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the project monitoring and control process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for monitoring performance against the project plan and managing corrective action to closure when actual performance or results deviate significantly from the plan. [PA162.EL101]

GP 2.2 (AB 1) Plan the Process

Establish and maintain the plan for performing the project monitoring and control process. *[GP104]*

Elaboration:

This plan for performing the project monitoring and control process is typically a part of the project plan, as described in the Project Planning process area. [PA162.EL102]

GP 2.3 (AB 2) Provide Resources

Provide adequate resources for performing the project monitoring and control process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Examples of resources provided include the following tools: [PA162.EL103]

- Cost tracking systems
- Effort reporting systems
- Action-item-tracking systems
- Project management and scheduling programs

GP 2.4 (AB 3) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the project monitoring and control process. *[GP106]*

GP 2.5 (AB 4) Train People

Train the people performing or supporting the project monitoring and control process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA162.EL104]

- Monitoring and control of projects
- Risk management
- Data management

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the project monitoring and control process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the project monitoring and control process as planned. *[GP124]*

Elaboration:

This generic practice is different from monitoring stakeholder interaction for the project, which is covered by a specific practice in this process area. [PA162.EL107]

Examples of activities for stakeholder involvement include the following: [PA162.EL108]

- Assessing the project against the plan
- Reviewing commitments and resolving issues
- Reviewing project risks
- Reviewing data management activities
- Reviewing project progress
- Managing corrective actions to closure

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the project monitoring and control process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA162.EL105]

- Number of open and closed corrective actions
- Project milestone dates (e.g., planned versus actual and slipped milestones)
- Number and types of reviews performed
- Review schedule (planned versus actual and slipped target dates)

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the project monitoring and control process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA162.EL106]

- Monitoring project performance against the project plan
- Managing corrective actions to closure

Examples of work products reviewed include the following: [PA162.EL109]

- Records of project performance
- Project review results

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the project monitoring and control process with higher level management and resolve issues. *[GP112]*

(The following goal is not required and its practices are not expected for a maturity level 2 rating, but are required for a maturity level 3 rating and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

GP 3.1 Establish a Defined Process

Establish and maintain the description of a defined project monitoring and control process. *[GP114]*

GP 3.2 Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the project monitoring and control process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

SUPPLIER AGREEMENT MANAGEMENT

Maturity Level 2

Purpose

The purpose of Supplier Agreement Management is to manage the acquisition of products from suppliers for which there exists a formal agreement. [PA166]

Introductory Notes

The Supplier Agreement Management process area involves the following: [PA166.N104]

- Determining the type of acquisition that will be used for the products to be acquired
- Selecting suppliers
- Establishing and maintaining agreements with suppliers
- Executing the supplier agreement
- Accepting delivery of acquired products
- Transitioning acquired products to the project

This process area primarily applies to the acquisition of products and product components that are delivered to the project's customer. To minimize risks to the project, this process area may also be applied to the acquisition of significant products and product components not delivered to the project's customer (for example, development tools and test environments). [PA166.N105]

This process area does not directly address arrangements in which the supplier is integrated into the project team (for example, integrated product teams). Typically, these situations are handled by other processes or functions, possibly external to the project, though some of the specific practices of this process area may be useful in managing the formal agreement with such a supplier. [PA166.N106]

Suppliers may take many forms depending on business needs, including in-house vendors (i.e., vendors that are in the same organization but are external to the project), fabrication capabilities and laboratories, and commercial vendors. [PA166.N103]

See the definition of "supplier" in Appendix C, the glossary. [PA166.N107]

A formal agreement is any legal agreement between the organization (representing the project) and the supplier. This agreement may be a contract, a license, or a memorandum of agreement. The acquired product is delivered to the project from the supplier and becomes part of the products delivered to the customer. [PA166.N101]

See Chapter 3 for an explanation of how "product" is used in the CMMI Product Suite. [PA166.N108]

Related Process Areas

Refer to the Project Monitoring and Control process area for more information about monitoring projects and taking corrective action. [PA166.R101]

Refer to the Requirements Development process area for more information about defining requirements. [PA166.R102]

Refer to the Requirements Management process area for more information about managing requirements, including the traceability of requirements for products acquired from suppliers. [PA166.R103]

Refer to the Technical Solution process area for more information about determining the products and product components that may be acquired from suppliers. [PA166.R104]

Specific and Generic Goals

SG 1 **Establish Supplier Agreements** [PA166.IG101]

Agreements with the suppliers are established and maintained.

SG 2 **Satisfy Supplier Agreements** [PA166.IG102]

Agreements with the suppliers are satisfied by both the project and the supplier.

GG 2 **Institutionalize a Managed Process** [CL103.GL101]

The process is institutionalized as a managed process.

(The following goal is not required for maturity level 2, but required for maturity level 3 and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Establish Supplier Agreements [PA166.IG101]

- SP 1.1 Determine Acquisition Type
- SP 1.2 Select Suppliers
- SP 1.3 Establish Supplier Agreements

SG 2 Satisfy Supplier Agreements [PA166.IG102]

- SP 2.1 Review COTS Products
- SP 2.2 Execute the Supplier Agreement
- SP 2.3 Accept the Acquired Product
- SP 2.4 Transition Products

GG 2 Institutionalize a Managed Process [CL103.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 2.2	(AB 1)	Plan the Process
GP 2.3	(AB 2)	Provide Resources
GP 2.4	(AB 3)	Assign Responsibility
GP 2.5	(AB 4)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

(The following goal is not required and its practices are not expected for a maturity level 2 rating, but are required and expected for a maturity level 3 rating and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

- GP 3.1 Establish a Defined Process
- GP 3.2 Collect Improvement Information

Specific Practices by Goal

SG 1 Establish Supplier Agreements

Agreements with the suppliers are established and maintained. [PA166.IG101]

SP 1.1 Determine Acquisition Type

Determine the type of acquisition for each product or product component to be acquired. [PA166.IG101.SP101]

Refer to the Technical Solution process area for more information about identifying the products and product components to be acquired. *[PA166.IG101.SP101.R101]*

There are many different types of acquisition that can be used to acquire products and product components that will be used by the project. [PA166.IG101.SP101.N106]

Examples of types of acquisition include the following: [PA166.IG101.SP101.N107]

- Purchasing commercial off-the-shelf (COTS) products
- Obtaining products through a contractual agreement
- Obtaining products from an in-house vendor
- Obtaining products from the customer
- Combining some of the above (e.g., contracting for a modification to a COTS product or having another part of the business enterprise co-develop products with an external supplier)

Typical Work Products

1. List of the acquisition types that will be used for all products and product components to be acquired [PA166.IG101.SP101.W101]

SP 1.2 Select Suppliers

Select suppliers based on an evaluation of their ability to meet the specified requirements and established criteria. *[PA166.IG101.SP102]*

Refer to the Decision Analysis and Resolution process area for more information about formal evaluation approaches that can be used to select suppliers. *[PA166.IG101.SP102.R101]*

Refer to the Requirements Management process area for more information about specified requirements. *[PA166.IG101.SP102.R102]*

Criteria should be established to address factors that are important to the project. [PA166.IG101.SP102.N101]

Examples of factors include the following: [PA166.IG101.SP102.N103]

- Geographical location of the supplier
- Supplier's performance records on similar work
- Engineering capabilities
- Staff and facilities available to perform the work
- Prior experience in similar applications

Typical Work Products

1. List of candidate suppliers [PA166.IG101.SP102.W101]
2. Preferred supplier list [PA166.IG101.SP102.W102]
3. Rationale for selection of suppliers [PA166.IG101.SP102.W103]
4. Advantages and disadvantages of candidate suppliers [PA166.IG101.SP102.W104]
5. Evaluation criteria [PA166.IG101.SP102.W105]
6. Solicitation materials and requirements [PA166.IG101.SP102.W106]

Subpractices

1. Establish and document criteria for evaluating potential suppliers. [PA166.IG101.SP102.SubP101]
2. Identify potential suppliers and distribute solicitation material and requirements to them. [PA166.IG101.SP102.SubP102]
3. Evaluate proposals according to evaluation criteria. [PA166.IG101.SP102.SubP103]
4. Evaluate risks associated with each proposed supplier. [PA166.IG101.SP102.SubP104]

   Refer to the Risk Management process area for more information about evaluating project risks. *[PA166.IG101.SP102.SubP104.R101]*

5. Evaluate proposed suppliers' ability to perform the work. [PA166.IG101.SP102.SubP105]

   Examples of methods to evaluate the proposed supplier's ability to perform the work include the following: [PA166.IG101.SP102.SubP105.N101]

   - Evaluation of prior experience in similar applications
   - Evaluation of prior performance on similar work
   - Evaluation of management capabilities
   - Capability evaluations
   - Evaluation of staff available to perform the work
   - Evaluation of available facilities and resources
   - Evaluation of the project's ability to work with the proposed supplier

6. Select the supplier. [PA166.IG101.SP102.SubP106]

SP 1.3 Establish Supplier Agreements

Establish and maintain formal agreements with the supplier.

[PA166.IG101.SP103]

For Integrated Product and Process Development

When integrated teams are formed, team membership should be negotiated with suppliers and incorporated into the agreement. The agreement should identify any integrated decision making, reporting requirements (business and technical), and trade studies requiring supplier involvement. The supplier efforts should be orchestrated to support the IPPD efforts undertaken by the acquirer. *[PA166.IG101.SP103.AMP101]*

A formal agreement is any legal agreement between the organization (representing the project) and the supplier. This agreement may be a contract, a license, or a memorandum of agreement. [PA166.IG101.SP103.N101]

Typical Work Products

1. Statements of work [PA166.IG101.SP103.W101]
2. Contracts [PA166.IG101.SP103.W102]
3. Memoranda of agreement [PA166.IG101.SP103.W103]
4. Licensing agreement [PA166.IG101.SP103.W104]

Subpractices

1. Revise the requirements to be fulfilled by the supplier to reflect negotiations with the supplier when necessary. [PA166.IG101.SP103.SubP101]

   Refer to the Requirements Development process area for more information about revising requirements. *[PA166.IG101.SP103.SubP101.R101]*

   Refer to the Requirements Management process area for more information about managing changes to requirements.
   [PA166.IG101.SP103.SubP101.R102]

2. Document what the project will provide to the supplier.
   [PA166.IG101.SP103.SubP102]

   Include the following: [PA166.IG101.SP103.SubP102.N101]

   - Project-furnished facilities
   - Documentation
   - Services

3. Document the supplier agreement. [PA166.IG101.SP103.SubP103]

   The supplier agreement should include a statement of work, a specification, terms and conditions, a list of deliverables, a schedule, a budget, and a defined acceptance process. [PA166.IG101.SP103.SubP103.N101]

This subpractice typically includes the following: [PA166.IG101.SP103.SubP103.N102]

- Establishing the statement of work, specification, terms and conditions, list of deliverables, schedule, budget, and acceptance process
- Identifying who from the project and supplier are responsible and authorized to make changes to the supplier agreement
- Identifying how requirements changes and changes to the supplier agreement are determined, communicated, and addressed
- Identifying standards and procedures that will be followed
- Identifying critical dependencies between the project and the supplier
- Identifying the type and depth of project oversight of the supplier, procedures, and evaluation criteria to be used in monitoring supplier performance
- Identifying the types of reviews that will be conducted with the supplier
- Identifying the supplier's responsibilities for ongoing maintenance and support of the acquired products
- Identifying warranty, ownership, and usage rights for the acquired products
- Identifying acceptance criteria

4. Ensure all parties to the agreement understand and agree to all requirements before implementing the agreement.
[PA166.IG101.SP103.SubP104]

5. Revise the supplier agreement as necessary. [PA166.IG101.SP103.SubP105]

6. Revise the project's plans and commitments as necessary to reflect the supplier agreement. [PA166.IG101.SP103.SubP106]

Refer to the Project Monitoring and Control process area for more information about revising the project plan. *[PA166.IG101.SP103.SubP106.R101]*

SG 2 Satisfy Supplier Agreements

Agreements with the suppliers are satisfied by both the project and the supplier. *[PA166.IG102]*

SP 2.1 Review COTS Products

Review candidate COTS products to ensure they satisfy the specified requirements that are covered under a supplier agreement. *[PA166.IG102.SP101]*

In the event that COTS products are desired, care in evaluating and selecting these products and the vendor may be critical to the project.
[PA166.IG102.SP101.N101]

Typical Work Products

1. Trade studies [PA166.IG102.SP101.W101]
2. Price lists [PA166.IG102.SP101.W102]
3. Evaluation criteria [PA166.IG102.SP101.W103]
4. Supplier performance reports [PA166.IG102.SP101.W104]
5. Reviews of COTS products [PA166.IG102.SP101.W105]

Subpractices

1. Develop criteria for evaluating COTS products. [PA166.IG102.SP101.SubP101]
2. Evaluate candidate COTS products against the associated requirements and criteria. [PA166.IG102.SP101.SubP102]

   Refer to the Requirements Development process area for more information about the requirements that will be used to evaluate candidate products. *[PA166.IG102.SP101.SubP102.R101]*

   These requirements address the following: [PA166.IG102.SP101.SubP102.N101]

   - Functionality, performance, quality, and reliability
   - Terms and conditions of warranties for the products
   - Risk
   - Suppliers' responsibilities for ongoing maintenance and support of the products
3. Evaluate the impact of candidate COTS products on the project's plans and commitments. [PA166.IG102.SP101.SubP103]

   Evaluate according to the following: [PA166.IG102.SP101.SubP103.N101]

   - Cost of the COTS products
   - Cost and effort to incorporate the COTS products into the project
   - Security requirements
   - Benefits and impacts that may result from future product releases

   Future product releases may provide additional features that support planned or anticipated enhancements for the project, but may also result in the supplier withdrawing support of the version for the product that is acquired by the project. [PA166.IG102.SP101.SubP103.N102]
4. Assess the suppliers' performance and ability to deliver. [PA166.IG102.SP101.SubP104]
5. Identify risks associated with the selected COTS product and the supplier agreement. [PA166.IG102.SP101.SubP105]

   Refer to the Project Planning process area for more information about identifying project risks. *[PA166.IG102.SP101.SubP105.R102]*

Refer to the Risk Management process area for more information about identifying project risks. [PA166.IG102.SP101.SubP105.R101]

6. Select the COTS product to be acquired. [PA166.IG102.SP101.SubP106]

   In some cases, selection of COTS products may require a supplier agreement in addition to the agreements in the product's license. [PA166.IG102.SP101.SubP106.N101]

   Examples of agreements with COTS suppliers include the following: [PA166.IG102.SP101.SubP106.N102]

   - Discounts for large quantity purchases
   - Coverage of relevant stakeholders under the licensing agreement, including project suppliers, team members, and the project's customer
   - Plans for future enhancements
   - On-site support, such as responses to queries and problem reports
   - Additional capabilities that are not in the product
   - Maintenance support, including support after the product is withdrawn from general availability

7. Plan for the maintenance of the COTS product. [PA166.IG102.SP101.SubP107]

SP 2.2 Execute the Supplier Agreement

Perform activities with the supplier as specified in the supplier agreement. *[PA166.IG102.SP102]*

Refer to the Project Monitoring and Control process area for more information about monitoring projects and taking corrective action. *[PA166.IG102.SP102.R101]*

Typical Work Products

1. Supplier progress reports and performance measures [PA166.IG102.SP102.W101]
2. Supplier review materials and reports [PA166.IG102.SP102.W103]
3. Action items tracked to closure [PA166.IG102.SP102.W104]
4. Documentation of product and document deliveries [PA166.IG102.SP102.W105]

Subpractices

1. Monitor supplier progress and performance (schedule, effort, cost, and technical performance) as defined in the supplier agreement. [PA166.IG102.SP102.SubP101]

2. Monitor selected supplier processes and take corrective action when necessary. [PA166.IG102.SP102.SubP102]

> Examples of processes to be monitored are quality assurance and configuration management. [PA166.IG102.SP102.SubP102.N101]

3. Conduct reviews with the supplier as specified in the supplier agreement. [PA166.IG102.SP102.SubP103]

Refer to the Project Monitoring and Control process area for more information about conducting reviews. *[PA166.IG102.SP102.SubP103.R101]*

Reviews cover both formal and informal reviews and include the following steps: [PA166.IG102.SP102.SubP103.N101]

- Preparing for the review
- Ensuring that relevant stakeholders participate
- Conducting the review
- Identifying, documenting, and tracking all action items to closure
- Preparing and distributing to the relevant stakeholders a summary report of the review

4. Conduct technical reviews with the supplier as defined in the supplier agreement. [PA166.IG102.SP102.SubP104]

Technical reviews typically include the following: [PA166.IG102.SP102.SubP104.N101]

- Providing the supplier with visibility into the needs and desires of the project's customers and end users, as appropriate
- Reviewing the supplier's technical activities and verifying that the supplier's interpretation and implementation of the requirements are consistent with the project's interpretation
- Ensuring that technical commitments are being met and that technical issues are communicated and resolved in a timely manner
- Obtaining technical information about the supplier's products
- Providing appropriate technical information and support to the supplier

5. Conduct management reviews with the supplier as defined in the supplier agreement. [PA166.IG102.SP102.SubP105]

Management reviews typically include the following: [PA166.IG102.SP102.SubP105.N101]

- Reviewing critical dependencies
- Reviewing project risks involving the supplier
- Reviewing schedule and budget

Technical and management reviews may be coordinated and held jointly. [PA166.IG102.SP102.SubP105.N102]

6. Use the results of reviews to improve the supplier's performance and to establish and nurture long-term relationships with preferred suppliers. [PA166.IG102.SP102.SubP106]

7. Monitor risks involving the supplier and take corrective action as necessary. [PA166.IG102.SP102.SubP107]

   Refer to the Project Monitoring and Control process area for more information about monitoring project risks. [PA166.IG102.SP102.SubP107.R101]

8. Revise the supplier agreement and project plans and schedules as necessary. [PA166.IG102.SP102.SubP108]

SP 2.3 Accept the Acquired Product

Ensure that the supplier agreement is satisfied before accepting the acquired product. [PA166.IG102.SP103]

Acceptance reviews and tests and configuration audits should be completed before accepting the product as defined in the supplier agreement. [PA166.IG102.SP103.N101]

Typical Work Products

1. Acceptance test procedures [PA166.IG102.SP103.W101]
2. Acceptance test results [PA166.IG102.SP103.W102]
3. Discrepancy reports or corrective action plans [PA166.IG102.SP103.W103]

Subpractices

1. Define the acceptance procedures. [PA166.IG102.SP103.SubP101]
2. Review and obtain agreement with relevant stakeholders on the acceptance procedures before the acceptance review or test. [PA166.IG102.SP103.SubP102]
3. Verify that the acquired products satisfy their requirements. [PA166.IG102.SP103.SubP103]

   Refer to the Verification process area for more information about verifying products. [PA166.IG102.SP103.SubP103.R101]

4. Confirm that the nontechnical commitments associated with the acquired work product are satisfied. [PA166.IG102.SP103.SubP104]

   This may include confirming that the appropriate license, warranty, ownership, usage, and support or maintenance agreements are in place and that all supporting materials are received. [PA166.IG102.SP103.SubP104.N101]

5. Document the results of the acceptance review or test. [PA166.IG102.SP103.SubP105]

6. Establish and obtain supplier agreement on an action plan for any acquired work products that do not pass their acceptance review or test. [PA166.IG102.SP103.SubP106]

7. Identify, document, and track action items to closure. [PA166.IG102.SP103.SubP107]

Refer to the Project Monitoring and Control process area for more information about tracking action items. *[PA166.IG102.SP103.SubP107.R101]*

SP 2.4 Transition Products

Transition the acquired products from the supplier to the project. *[PA166.IG102.SP104]*

Before the acquired product is transferred to the project for integration, appropriate planning and evaluation should occur to ensure a smooth transition. [PA166.IG102.SP104.N101]

Refer to the Product Integration process area for more information about integrating the acquired products. *[PA166.IG102.SP104.N101.R101]*

Typical Work Products

1. Transition plans [PA166.IG102.SP104.W101]
2. Training reports [PA166.IG102.SP104.W102]
3. Support and maintenance reports [PA166.IG102.SP104.W103]

Subpractices

1. Ensure that there are appropriate facilities to receive, store, use, and maintain the acquired products. [PA166.IG102.SP104.SubP101]
2. Ensure that appropriate training is provided for those involved in receiving, storing, using, and maintaining the acquired products. [PA166.IG102.SP104.SubP102]
3. Ensure that storing, distributing, and using the acquired products are performed according to the terms and conditions specified in the supplier agreement or license. [PA166.IG102.SP104.SubP103]

GG 2 Institutionalize a Managed Process [CL103.GL101]

The process is institutionalized as a managed process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the supplier agreement management process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for establishing, maintaining, and satisfying supplier agreements. [PA166.EL101]

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the plan for performing the supplier agreement management process. *[GP104]*

Elaboration:

Typically, portions of this plan for performing the supplier agreement management process are a part of the project plan as described in the Project Planning process area. Often, however, some portions of the plan reside outside of the project with an independent group, such as contract management. [PA166.EL110]

GP 2.3 (AB 2) Provide Resources

Provide adequate resources for performing the supplier agreement management process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Examples of resources provided include the following tools: [PA166.EL102]

- Preferred supplier lists
- Requirements tracking programs
- Project management and scheduling programs

GP 2.4 (AB 3) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the supplier agreement management process. *[GP106]*

GP 2.5 (AB 4) Train People

Train the people performing or supporting the supplier agreement management process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA166.EL103]

- Regulations and business practices related to negotiating and working with suppliers
- Acquisition planning and preparation
- COTS products acquisition
- Supplier evaluation and selection
- Negotiation and conflict resolution
- Supplier management
- Testing and transitioning of acquired products
- Receiving, storing, using, and maintaining acquired products

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the supplier agreement management process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA166.EL104]

- Statements of work
- Supplier agreements
- Memoranda of agreement
- Subcontracts
- Preferred supplier lists

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the supplier agreement management process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include the following: [PA166.EL109]

- Establishing criteria for evaluation of potential suppliers
- Reviewing potential suppliers
- Establishing supplier agreements
- Resolving issues with suppliers
- Reviewing supplier performance

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the supplier agreement management process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA166.EL105]

- Number of changes made to the requirements for the supplier
- Cost and schedule variance per supplier agreement

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the supplier agreement management process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA166.EL106]

- Establishing and maintaining supplier agreements
- Satisfying supplier agreements

Examples of work products reviewed include the following: [PA166.EL108]

- Plan for Supplier Agreement Management
- Supplier agreements

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the supplier agreement management process with higher level management and resolve issues. *[GP112]*

(The following goal is not required and its practices are not expected for a maturity level 2 rating, but are required for a maturity level 3 rating and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

GP 3.1 Establish a Defined Process

Establish and maintain the description of a defined supplier agreement management process. *[GP114]*

GP 3.2 Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the supplier agreement management process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

MEASUREMENT AND ANALYSIS

Maturity Level 2

Purpose

The purpose of Measurement and Analysis is to develop and sustain a measurement capability that is used to support management information needs. [PA154]

Introductory Notes

The Measurement and Analysis process area involves the following: [PA154.N101]

- Specifying the objectives of measurement and analysis such that they are aligned with identified information needs and objectives
- Specifying the measures, data collection and storage mechanisms, analysis techniques, and reporting and feedback mechanisms
- Implementing the collection, storage, analysis, and reporting of the data
- Providing objective results that can be used in making informed decisions, and taking appropriate corrective actions

The integration of measurement and analysis activities into the processes of the project supports the following: [PA154.N102]

- Objective planning and estimating
- Tracking actual performance against established plans and objectives
- Identifying and resolving process-related issues
- Providing a basis for incorporating measurement into additional processes in the future

The staff required to implement a measurement capability may or may not be employed in a separate organization-wide program. Measurement capability may be integrated into individual projects or other organizational functions (e.g., Quality Assurance). [PA154.N103]

The initial focus for measurement activities is at the project level. However, a measurement capability may prove useful for addressing organization- and/or enterprise-wide information needs. [PA154.N104]

Projects may choose to store project-specific data and results in a project-specific repository. When data are shared more widely across projects, the data may reside in the organization's measurement repository. [PA154.N105]

Related Process Areas

Refer to the Project Planning process area for more information about estimating project attributes and other planning information needs. *[PA154.R101]*

Refer to the Project Monitoring & Control process area for more information about monitoring project performance information needs. *[PA154.R102]*

Refer to the Configuration Management process area for more information about managing measurement work products. *[PA154.R103]*

Refer to the Requirements Development process area for more information about meeting customer requirements and related information needs. *[PA154.R104]*

Refer to the Requirements Management process area for more information about maintaining requirements traceability and related information needs. *[PA154.R105]*

Refer to the Organizational Process Definition process area for more information about establishing the organization's measurement repository. *[PA154.R106]*

Refer to the Quantitative Project Management process area for more information about understanding variation and the appropriate use of statistical analysis techniques. *[PA154.R107]*

Specific and Generic Goals

SG 1 Align Measurement and Analysis Activities [PA154.IG101]

Measurement objectives and activities are aligned with identified information needs and objectives.

SG 2 Provide Measurement Results [PA154.IG102]

Measurement results that address identified information needs and objectives are provided.

GG 2 Institutionalize a Managed Process [CL103.GL101]

The process is institutionalized as a managed process.

(The following goal is not required for maturity level 2, but required for maturity level 3 and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Align Measurement and Analysis Activities [PA154.IG101]

- SP 1.1 Establish Measurement Objectives
- SP 1.2 Specify Measures
- SP 1.3 Specify Data Collection and Storage Procedures
- SP 1.4 Specify Analysis Procedures

SG 2 Provide Measurement Results [PA154.IG102]

- SP 2.1 Collect Measurement Data
- SP 2.2 Analyze Measurement Data
- SP 2.3 Store Data and Results
- SP 2.4 Communicate Results

GG 2 Institutionalize a Managed Process [CL103.GL101]

- GP 2.1 (CO 1) Establish an Organizational Policy
- GP 2.2 (AB 1) Plan the Process
- GP 2.3 (AB 2) Provide Resources
- GP 2.4 (AB 3) Assign Responsibility
- GP 2.5 (AB 4) Train People
- GP 2.6 (DI 1) Manage Configurations
- GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders
- GP 2.8 (DI 3) Monitor and Control the Process
- GP 2.9 (VE 1) Objectively Evaluate Adherence
- GP 2.10 (VE 2) Review Status with Higher Level Management

(The following goal is not required and its practices are not expected for a maturity level 2 rating, but are required and expected for a maturity level 3 rating and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

- GP 3.1 Establish a Defined Process
- GP 3.2 Collect Improvement Information

Specific Practices by Goal

SG 1 Align Measurement and Analysis Activities

Measurement objectives and activities are aligned with identified information needs and objectives. [PA154.IG101]

The specific practices covered under this specific goal may be addressed concurrently or in any order: [PA154.IG101.N101]

- When establishing measurement objectives, experts often think ahead about necessary criteria for specifying measures and analysis procedures. They also think concurrently about the constraints imposed by data collection and storage procedures.
- It often is important to specify the essential analyses that will be conducted before attending to details of measurement specification, data collection, or storage.

SP 1.1 Establish Measurement Objectives

Establish and maintain measurement objectives that are derived from identified information needs and objectives. *[PA154.IG101.SP101]*

Measurement objectives document the purposes for which measurement and analysis are done, and specify the kinds of actions that may be taken based on the results of data analyses.
[PA154.IG101.SP101.N101]

The sources for measurement objectives may be management, technical, project, product, or process implementation needs.
[PA154.IG101.SP101.N102]

The measurement objectives may be constrained by existing processes, available resources, or other measurement considerations. Judgments may need to be made about whether the value of the results will be commensurate with the resources devoted to doing the work.
[PA154.IG101.SP101.N103]

Modifications to identified information needs and objectives may, in turn, be indicated as a consequence of the process and results of measurement and analysis. [PA154.IG101.SP101.N104]

Sources of information needs and objectives may include the following:
[PA154.IG101.SP101.N105]

- Project plans
- Monitoring of project performance
- Interviews with managers and others who have information needs
- Established management objectives
- Strategic plans
- Business plans
- Formal requirements or contractual obligations
- Recurring or other troublesome management or technical problems

- Experiences of other projects or organizational entities
- External industry benchmarks
- Process-improvement plans

Refer to the Project Planning process area for more information about estimating project attributes and other planning information needs. *[PA154.IG101.SP101.N105.R101]*

Refer to the Project Monitoring and Control process area for more information about project performance information needs. *[PA154.IG101.SP101.N105.R102]*

Refer to the Requirements Development process area for more information about meeting customer requirements and related information needs. *[PA154.IG101.SP101.N105.R103]*

Refer to the Requirements Management process area for more information about maintaining requirements traceability and related information needs. *[PA154.IG101.SP101.N105.R104]*

Typical Work Products

1. Measurement objectives [PA154.IG101.SP101.W101]

Subpractices

1. Document information needs and objectives. [PA154.IG101.SP101.SubP101]

   Information needs and objectives are documented to allow traceability to subsequent measurement and analysis activities. [PA154.IG101.SP101.SubP101.N101]

2. Prioritize information needs and objectives. [PA154.IG101.SP101.SubP102]

   It may be neither possible nor desirable to subject all initially identified information needs to measurement and analysis. Priorities may also need to be set within the limits of available resources. [PA154.IG101.SP101.SubP102.N101]

3. Document, review, and update measurement objectives. [PA154.IG101.SP101.SubP103]

   It is important to carefully consider the purposes and intended uses of measurement and analysis. [PA154.IG101.SP101.SubP103.N101]

   The measurement objectives are documented, reviewed by management and other relevant stakeholders, and updated as necessary. Doing so enables traceability to subsequent measurement and analysis activities, and helps ensure that the analyses will properly address identified information needs and objectives. [PA154.IG101.SP101.SubP103.N102]

It is important that users of measurement and analysis results be involved in setting measurement objectives and deciding on plans of action. It may also be appropriate to involve those who provide the measurement data. [PA154.IG101.SP101.SubP103.N103]

4. Provide feedback for refining and clarifying information needs and objectives as necessary. [PA154.IG101.SP101.SubP104]

   Identified information needs and objectives may need to be refined and clarified as a result of setting measurement objectives. Initial descriptions of information needs may be unclear or ambiguous. Conflicts may arise between existing needs and objectives. Precise targets on an already existing measure may be unrealistic. [PA154.IG101.SP101.SubP104.N101]

5. Maintain traceability of the measurement objectives to the identified information needs and objectives. [PA154.IG101.SP101.SubP105]

   There must always be a good answer to the question, "Why are we measuring this?" [PA154.IG101.SP101.SubP105.N101]

   Of course, the measurement objectives may also change to reflect evolving information needs and objectives. [PA154.IG101.SP101.SubP105.N102]

SP 1.2 Specify Measures

Specify measures to address the measurement objectives.

[PA154.IG101.SP102]

Measurement objectives are refined into precise, quantifiable measures. [PA154.IG101.SP102.N101]

Measures may be either "base" or "derived." Data for base measures are obtained by direct measurement. Data for derived measures come from other data, typically by combining two or more base measures. [PA154.IG101.SP102.N102]

Examples of commonly used base measures include the following: [PA154.IG101.SP102.N103]

- Estimates and actual measures of work product size (e.g., number of pages)
- Estimates and actual measures of effort and cost (e.g., number of person hours)
- Quality measures (e.g., number of defects, number of defects by severity)

Examples of commonly used derived measures include the following: [PA154.IG101.SP102.N104]

- Earned Value
- Schedule Performance Index
- Defect density
- Peer review coverage
- Test or verification coverage
- Reliability measures (e.g., mean time to failure)
- Quality measures (e.g., number of defects by severity/total number of defects)

Derived measures typically are expressed as ratios, composite indices, or other aggregate summary measures. They are often more quantitatively reliable and meaningfully interpretable than the base measures used to generate them. [PA154.IG101.SP102.N105]

Typical Work Products

1. Specifications of base and derived measures [PA154.IG101.SP102.W101]

Subpractices

1. Identify candidate measures based on documented measurement objectives. [PA154.IG101.SP102.SubP101]

   The measurement objectives are refined into specific measures. The identified candidate measures are categorized and specified by name and unit of measure. [PA154.IG101.SP102.SubP101.N101]

2. Identify existing measures that already address the measurement objectives. [PA154.IG101.SP102.SubP102]

   Specifications for measures may already exist, perhaps established for other purposes earlier or elsewhere in the organization. [PA154.IG101.SP102.SubP102.N101]

3. Specify operational definitions for the measures. [PA154.IG101.SP102.SubP103]

   Operational definitions are stated in precise and unambiguous terms. They address two important criteria as follows: [PA154.IG101.SP102.SubP103.N101]

   - Communication: What has been measured, how was it measured, what are the units of measure, and what has been included or excluded?
   - Repeatability: Can the measurement be repeated, given the same definition, to get the same results?

4. Prioritize, review, and update measures. [PA154.IG101.SP102.SubP104]

   Proposed specifications of the measures are reviewed for their appropriateness with potential end users and other relevant stakeholders. Priorities are set or changed, and specifications of the measures are updated as necessary. [PA154.IG101.SP102.SubP104.N101]

SP 1.3 Specify Data Collection and Storage Procedures

Specify how measurement data will be obtained and stored.

[PA154.IG101.SP103]

Explicit specification of collection methods helps ensure that the right data are collected properly. It may also aid in further clarifying information needs and measurement objectives. [PA154.IG101.SP103.N101]

Proper attention to storage and retrieval procedures helps ensure that data are available and accessible for future use. [PA154.IG101.SP103.N102]

Typical Work Products

1. Data collection and storage procedures [PA154.IG101.SP103.W101]
2. Data collection tools [PA154.IG101.SP103.W102]

Subpractices

1. Identify existing sources of data that are generated from current work products, processes, or transactions. [PA154.IG101.SP103.SubP101]

   Existing sources of data may already have been identified when specifying the measures. Appropriate collection mechanisms may exist whether or not pertinent data have already been collected. [PA154.IG101.SP103.SubP101.N101]

2. Identify measures for which data are needed, but are not currently available. [PA154.IG101.SP103.SubP102]
3. Specify how to collect and store the data for each required measure. [PA154.IG101.SP103.SubP103]

   Explicit specifications are made of how, where, and when the data will be collected. Procedures for collecting valid data are specified. The data are stored in an accessible manner for analysis, and it is determined whether they will be saved for possible reanalysis or documentation purposes. [PA154.IG101.SP103.SubP103.N101]

   Questions to be considered typically include the following: [PA154.IG101.SP103.SubP103.N102]

   - Have the frequency of collection and the points in the process where measurements will be made been determined?
   - Has the time line that is required to move measurement results from the points of collection to repositories, other databases, or end users been established?
   - Who is responsible for obtaining the data?
   - Who is responsible for data storage, retrieval, and security?
   - Have necessary supporting tools been developed or acquired?

4. Create data collection mechanisms and process guidance. [PA154.IG101.SP103.SubP104]

Data collection and storage mechanisms are well integrated with other normal work processes. Data collection mechanisms may include manual or automated forms and templates. Clear, concise guidance on correct procedures is available to those responsible for doing the work. Training is provided as necessary to clarify the processes necessary for collection of complete and accurate data and to minimize the burden on those who must provide and record the data. [PA154.IG101.SP103.SubP104.N101]

5. Support automatic collection of the data where appropriate and feasible. [PA154.IG101.SP103.SubP105]

Automated support can aid in collecting more complete and accurate data. [PA154.IG101.SP103.SubP105.N101]

Examples of such automated support include the following: [PA154.IG101.SP103.SubP105.N102]

- Timestamped activity logs
- Static or dynamic analyses of artifacts

However, some data cannot be collected without human intervention (e.g., customer satisfaction or other human judgments), and setting up the necessary infrastructure for other automation may be costly. [PA154.IG101.SP103.SubP105.N103]

6. Prioritize, review, and update data collection and storage procedures. [PA154.IG101.SP103.SubP106]

Proposed procedures are reviewed for their appropriateness and feasibility with those who are responsible for providing, collecting, and storing the data. They also may have useful insights about how to improve existing processes, or be able to suggest other useful measures or analyses. [PA154.IG101.SP103.SubP106.N101]

7. Update measures and measurement objectives as necessary. [PA154.IG101.SP103.SubP107]

Priorities may need to be reset based on the following: [PA154.IG101.SP103.SubP107.N101]

- The importance of the measures
- The amount of effort required to obtain the data

Considerations include whether new forms, tools, or training would be required to obtain the data. [PA154.IG101.SP103.SubP107.N102]

SP 1.4 Specify Analysis Procedures

Specify how measurement data will be analyzed and reported. *[PA154.IG101.SP104]*

Specifying the analysis procedures in advance ensures that appropriate analyses will be conducted and reported to address the documented measurement objectives (and thereby the information needs and objectives on which they are based). This approach also provides a check that the necessary data will in fact be collected. [PA154.IG101.SP104.N101]

Typical Work Products

1. Analysis specification and procedures [PA154.IG101.SP104.W101]
2. Data analysis tools [PA154.IG101.SP104.W102]

Subpractices

1. Specify and prioritize the analyses that will be conducted and the reports that will be prepared. [PA154.IG101.SP104.SubP101]

   Early attention should be paid to the analyses that will be conducted and to the manner in which the results will be reported. These should meet the following criteria: [PA154.IG101.SP104.SubP101.N101]

   - The analyses explicitly address the documented measurement objectives
   - Presentation of the results is clearly understandable by the audiences to whom the results are addressed

   Priorities may have to be set within available resources. [PA154.IG101.SP104.SubP101.N102]

2. Select appropriate data analysis methods and tools.
   [PA154.IG101.SP104.SubP102]

   Refer to the Select Measures and Analytic Techniques and Apply Statistical Methods to Understand Variation specific practices of the Quantitative Project Management process area for more information about the appropriate use of statistical analysis techniques and understanding variation, respectively.
   [PA154.IG101.SP104.SubP102.R101]

   Issues to be considered typically include the following: [PA154.IG101.SP104.SubP102.N101]

   - Choice of visual display and other presentation techniques (e.g., pie charts, bar charts, histograms, radar charts, line graphs, scatter plots, or tables)
   - Choice of appropriate descriptive statistics (e.g., arithmetic mean, median, or mode)
   - Decisions about statistical sampling criteria when it is impossible or unnecessary to examine every data element
   - Decisions about how to handle analysis in the presence of missing data elements
   - Selection of appropriate analysis tools

   Descriptive statistics are typically used in data analysis to do the following:
   [PA154.IG101.SP104.SubP102.N102]

- Examine distributions on the specified measures (e.g., central tendency, extent of variation, data points exhibiting unusual variation)
- Examine the interrelationships among the specified measures (e.g., comparisons of defects by phase of the product's life cycle or by product component)
- Display changes over time

3. Specify administrative procedures for analyzing the data and communicating the results. [PA154.IG101.SP104.SubP103]

   Issues to be considered typically include the following: [PA154.IG101.SP104.SubP103.N101]

   - Identifying the persons and groups responsible for analyzing the data and presenting the results
   - Determining the time line to analyze the data and present the results
   - Determining the venues for communicating the results (e.g., progress reports, transmittal memos, written reports, or staff meetings)

4. Review and update the proposed content and format of the specified analyses and reports. [PA154.IG101.SP104.SubP104]

   All of the proposed content and format are subject to review and revision, including analytic methods and tools, administrative procedures, and priorities. The relevant stakeholders consulted should include intended end users, sponsors, data analysts, and data providers. [PA154.IG101.SP104.SubP104.N101]

5. Update measures and measurement objectives as necessary. [PA154.IG101.SP104.SubP105]

   Just as measurement needs drive data analysis, clarification of analysis criteria can affect measurement. Specifications for some measures may be refined further based on the specifications established for data analysis procedures. Other measures may prove to be unnecessary, or a need for additional measures may be recognized. [PA154.IG101.SP104.SubP105.N101]

   The exercise of specifying how measures will be analyzed and reported may also suggest the need for refining the measurement objectives themselves. [PA154.IG101.SP104.SubP105.N102]

6. Specify criteria for evaluating the utility of the analysis results, and of the conduct of the measurement and analysis activities. [PA154.IG101.SP104.SubP106]

   Criteria for evaluating the utility of the analysis might address the extent to which the following apply: [PA154.IG101.SP104.SubP106.N101]

   - The results are (1) provided on a timely basis, (2) understandable, and (3) used for decision making.
   - The work does not cost more to perform than is justified by the benefits that it provides.

Criteria for evaluating the conduct of the measurement and analysis might include the extent to which the following apply: [PA154.IG101.SP104.SubP106.N102]

- The amount of missing data or the number of flagged inconsistencies is beyond specified thresholds.
- There is selection bias in sampling (e.g., only satisfied end users are surveyed to evaluate end-user satisfaction, or only unsuccessful projects are evaluated to determine overall productivity).
- The measurement data are repeatable (e.g., statistically reliable).
- Statistical assumptions have been satisfied (e.g., about the distribution of data or about appropriate measurement scales).

SG 2 Provide Measurement Results

Measurement results that address identified information needs and objectives are provided. *[PA154.IG102]*

The primary reason for doing measurement and analysis is to address identified information needs and objectives. Measurement results based on objective evidence can help to monitor performance, fulfill contractual obligations, make informed management and technical decisions, and enable corrective actions to be taken. [PA154.IG102.N101]

SP 2.1 Collect Measurement Data

Obtain specified measurement data. *[PA154.IG102.SP101]*

The data necessary for analysis are obtained and checked for completeness and integrity. [PA154.IG102.SP101.N101]

Typical Work Products

1. Base and derived measurement data sets [PA154.IG102.SP101.W101]
2. Results of data integrity tests [PA154.IG102.SP101.W102]

Subpractices

1. Obtain the data for base measures. [PA154.IG102.SP101.SubP101]

   Data are collected as necessary for previously used as well as for newly specified base measures. Existing data are gathered from project records or from elsewhere in the organization. [PA154.IG102.SP101.SubP101.N101]

   Note that data that were collected earlier may no longer be available for reuse in existing databases, paper records, or formal repositories. [PA154.IG102.SP101.SubP101.N102]

2. Generate the data for derived measures. [PA154.IG102.SP101.SubP102]

   Values are newly calculated for all derived measures. [PA154.IG102.SP101.SubP102.N101]

3. Perform data integrity checks as close to the source of the data as possible. [PA154.IG102.SP101.SubP103]

   All measurements are subject to error in specifying or recording data. It is always better to identify such errors and to identify sources of missing data early in the measurement and analysis cycle. [PA154.IG102.SP101.SubP103.N101]

   Checks can include scans for missing data, out-of-bounds data values, and unusual patterns and correlation across measures. [PA154.IG102.SP101.SubP103.N102]

   It is particularly important to do the following: [PA154.IG102.SP101.SubP103.N103]

   - Test and correct for inconsistency of classifications made by human judgment (i.e., to determine how frequently people make differing classification decisions based on the same information, otherwise known as "inter-coder reliability").
   - Empirically examine the relationships among the measures that are used to calculate additional derived measures. Doing so can ensure that important distinctions are not overlooked and that the derived measures convey their intended meanings (otherwise known as "criterion validity").

SP 2.2 Analyze Measurement Data

Analyze and interpret measurement data. *[PA154.IG102.SP102]*

The measurement data are analyzed as planned, additional analyses are conducted as necessary, results are reviewed with relevant stakeholders, and necessary revisions for future analyses are noted. [PA154.IG102.SP102.N101]

Typical Work Products

1. Analysis results and draft reports [PA154.IG102.SP102.W101]

Subpractices

1. Conduct initial analyses, interpret the results, and draw preliminary conclusions. [PA154.IG102.SP102.SubP101]

   The results of data analyses are rarely self evident. Criteria for interpreting the results and drawing conclusions should be stated explicitly. [PA154.IG102.SP102.SubP101.N101]

2. Conduct additional measurement and analysis as necessary, and prepare results for presentation. [PA154.IG102.SP102.SubP102]

   The results of planned analyses may suggest (or require) additional, unanticipated analyses. In addition, they may identify needs to refine existing measures, to calculate additional derived measures, or even to collect data for additional primitive measures to properly complete the planned analysis. Similarly, preparing the initial results for presentation may identify the need for additional, unanticipated analyses. [PA154.IG102.SP102.SubP102.N101]

3. Review the initial results with relevant stakeholders.
[PA154.IG102.SP102.SubP103]

It may be appropriate to review initial interpretations of the results and the way in which they are presented before disseminating and communicating them more widely. [PA154.IG102.SP102.SubP103.N101]

Reviewing the initial results before their release may prevent needless misunderstandings and lead to improvements in the data analysis and presentation. [PA154.IG102.SP102.SubP103.N102]

Relevant stakeholders with whom reviews may be conducted include intended end users and sponsors, as well as data analysts and data providers.
[PA154.IG102.SP102.SubP103.N103]

4. Refine criteria for future analyses. [PA154.IG102.SP102.SubP104]

Valuable lessons that can improve future efforts are often learned from conducting data analyses and preparing results. Similarly, ways to improve measurement specifications and data collection procedures may become apparent, as may ideas for refining identified information needs and objectives.
[PA154.IG102.SP102.SubP104.N101]

SP 2.3 Store Data and Results

Manage and store measurement data, measurement specifications, and analysis results. *[PA154.IG102.SP103]*

Storing measurement-related information enables the timely and cost-effective future use of historical data and results. The information also is needed to provide sufficient context for interpretation of the data, measurement criteria, and analysis results. [PA154.IG102.SP103.N101]

Information stored typically includes the following: [PA154.IG102.SP103.N102]

- Measurement plans
- Specifications of measures
- Sets of data that have been collected
- Analysis reports and presentations

The stored information contains or references the information needed to understand and interpret the measures and assess them for reasonableness and applicability (e.g., measurement specifications used on different projects when comparing across projects).
[PA154.IG102.SP103.N103]

Data sets for derived measures typically can be recalculated and need not be stored. However, it may be appropriate to store summaries based on derived measures (e.g., charts, tables of results, or report prose). [PA154.IG102.SP103.N104]

Interim analysis results need not be stored separately if they can be efficiently reconstructed. [PA154.IG102.SP103.N105]

Projects may choose to store project-specific data and results in a project-specific repository. When data are shared more widely across projects, the data may reside in the organization's measurement repository. [PA154.IG102.SP103.N106]

Refer to the Establish the Organization's Measurement Repository specific practice of the Organizational Process Definition process area for more information about establishing the organization's measurement repository. *[PA154.IG102.SP103.N106.R101]*

Refer to the Configuration Management process area for information on managing measurement work products. *[PA154.IG102.SP103.N106.R102]*

Typical Work Products

1. Stored data inventory [PA154.IG102.SP103.W101]

Subpractices

1. Review the data to ensure their completeness, integrity, accuracy, and currency. [PA154.IG102.SP103.SubP101]
2. Make the stored contents available for use only by appropriate groups and personnel. [PA154.IG102.SP103.SubP102]
3. Prevent the stored information from being used inappropriately. [PA154.IG102.SP103.SubP103]

Examples of ways to prevent inappropriate use of the data and related information include controlling access to data and educating people on the appropriate use of data. [PA154.IG102.SP103.SubP103.N101]

Examples of inappropriate use include the following: [PA154.IG102.SP103.SubP103.N102]

- Disclosure of information that was provided in confidence
- Faulty interpretations based on incomplete, out-of-context, or otherwise misleading information
- Measures used to improperly evaluate the performance of people or to rank projects
- Impugning the integrity of specific individuals

SP 2.4 Communicate Results

Report results of measurement and analysis activities to all relevant stakeholders. *[PA154.IG102.SP104]*

The results of the measurement and analysis process are communicated to relevant stakeholders in a timely and usable fashion to support decision making and assist in taking corrective action.
[PA154.IG102.SP104.N101]

Relevant stakeholders include intended users, sponsors, data analysts, and data providers. [PA154.IG102.SP104.N102]

Typical Work Products

1. Delivered reports and related analysis results [PA154.IG102.SP104.W101]
2. Contextual information or guidance to aid in the interpretation of analysis results [PA154.IG102.SP104.W102]

Subpractices

1. Keep relevant stakeholders apprised of measurement results on a timely basis. [PA154.IG102.SP104.SubP101]

   Measurement results are communicated in time to be used for their intended purposes. Reports are unlikely to be used if they are distributed with little effort to follow up with those who need to know the results. [PA154.IG102.SP104.SubP101.N101]

   To the extent possible and as part of the normal way they do business, users of measurement results are kept personally involved in setting objectives and deciding on plans of action for measurement and analysis. The users are regularly kept apprised of progress and interim results. [PA154.IG102.SP104.SubP101.N102]

   Refer to the Project Monitoring and Control process area for more information on the use of measurement results.
   [PA154.IG102.SP104.SubP101.N102.R101]

2. Assist relevant stakeholders in understanding the results.
   [PA154.IG102.SP104.SubP102]

   Results are reported in a clear and concise manner appropriate to the methodological sophistication of the relevant stakeholders. They are understandable, easily interpretable, and clearly tied to identified information needs and objectives. [PA154.IG102.SP104.SubP102.N101]

   The data are often not self evident to practitioners who are not measurement experts. Measurement choices should be explicitly clear about the following:
   [PA154.IG102.SP104.SubP102.N102]

   - How and why the base and derived measures were specified
   - How the data were obtained

- How to interpret the results based on the data analysis methods that were used
- How the results address their information needs

Examples of actions to assist in understanding of results include the following: [PA154.IG102.SP104.SubP102.N103]

- Discussing the results with the relevant stakeholders
- Providing a transmittal memo that provides background and explanation
- Briefing users on the results
- Providing training on the appropriate use and understanding of measurement results

GG 2 Institutionalize a Managed Process [CL103.GL101]

The process is institutionalized as a managed process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the measurement and analysis process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for aligning measurement objectives and activities with identified information needs and objecfives and for providing measurement results. [PA154.EL101]

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the plan for performing the measurement and analysis process. *[GP104]*

Elaboration:

Typically, this plan for performing the measurement and analysis process is included in (or referenced by) the project plan, which is described in the Project Planning process area. [PA154.EL115]

GP 2.3 (AB 2) Provide Resources

Provide adequate resources for performing the measurement and analysis process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Measurement personnel may be employed full time or part time. A measurement group may or may not exist to support measurement activities across multiple projects. [PA154.EL104]

Examples of other resources provided include the following tools: [PA154.EL105]

- Statistical packages
- Packages that support data collection over networks

GP 2.4 (AB 3) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the measurement and analysis process. *[GP106]*

GP 2.5 (AB 4) Train People

Train the people performing or supporting the measurement and analysis process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA154.EL107]

- Statistical techniques
- Data collection, analysis, and reporting processes
- Development of goal-related measurements (e.g., Goal Question Metric)

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the measurement and analysis process under appropriate levels of configuration management.

[GP109]

Elaboration:

Examples of work products placed under configuration management include the following: [PA154.EL108]

- Specifications of base and derived measures
- Data collection and storage procedures
- Base and derived measurement data sets
- Analysis results and draft reports
- Data analysis tools

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the measurement and analysis process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include the following: [PA154.EL114]

- Establishing measurement objectives and procedures
- Assessing measurement data
- Providing meaningful feedback to those responsible for providing the raw data on which the analysis and results depend

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the measurement and analysis process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA154.EL111]

- Percentage of projects using progress and performance measures
- Percentage of measurement objectives addressed

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the measurement and analysis process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA154.EL112]

- Aligning measurement and analysis activities
- Providing measurement results

Examples of work products reviewed include the following: [PA154.EL113]

- Specifications of base and derived measures
- Data collection and storage procedures
- Analysis results and draft reports

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the measurement and analysis process with higher level management and resolve issues. *[GP112]*

(The following goal is not required and its practices are not expected for a maturity level 2 rating, but are required for a maturity level 3 rating and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

GP 3.1 Establish a Defined Process

Establish and maintain the description of a defined measurement and analysis process. *[GP114]*

GP 3.2 Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the measurement and analysis process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

PROCESS AND PRODUCT QUALITY ASSURANCE

Maturity Level 2

Purpose

The purpose of Process and Product Quality Assurance is to provide staff and management with objective insight into processes and associated work products. [PA145]

Introductory Notes

The Process and Product Quality Assurance process area involves the following: [PA145.N101]

- Objectively evaluating performed processes, work products, and services against the applicable process descriptions, standards, and procedures
- Identifying and documenting noncompliance issues
- Providing feedback to project staff and managers on the results of quality assurance activities
- Ensuring that noncompliance issues are addressed

The Process and Product Quality Assurance process area supports the delivery of high-quality products and services by providing the project staff and managers at all levels with appropriate visibility into, and feedback on, processes and associated work products throughout the life of the project. [PA145.N102]

The practices in the Process and Product Quality Assurance process area ensure that planned processes are implemented, while the practices in the Verification process area ensure that the specified requirements are satisfied. These two process areas may on occasion address the same work product but from different perspectives. Projects should take care to minimize duplication of effort. [PA145.N103]

Objectivity in process and product quality assurance evaluations is critical to the success of the project. (See the definition of "objectively evaluate" in Appendix C, the glossary.) Objectivity is achieved by both independence and the use of criteria. Traditionally, a quality assurance group that is independent of the project provides this objectivity. It may be appropriate in some organizations, however, to implement the process and product quality assurance role without that kind of independence. For example, in an organization with an open, quality-oriented culture, the process and product quality assurance role may be performed, partially or completely, by peers; and the quality assurance function may be embedded in the process. [PA145.N104]

If quality assurance is embedded in the process, several issues must be addressed to ensure objectivity. Everyone performing quality assurance activities should be trained in quality assurance. Those performing quality assurance activities for a work product should be separate from those directly involved in developing or maintaining the work product. An independent reporting channel to the appropriate level of organizational management must be available so that noncompliance issues may be escalated as necessary. [PA145.N105]

Quality assurance should begin in the early phases of a project to establish plans, processes, standards, and procedures that will add value to the project and satisfy the requirements of the project and the organizational policies. Those performing quality assurance participate in establishing the plans, processes, standards, and procedures to ensure that they fit the project's needs and that they will be useable for performing quality assurance evaluations. In addition, the specific processes and associated work products that will be evaluated during the project are designated. This designation may be based on sampling or on objective criteria that are consistent with organizational policies and project requirements and needs. [PA145.N106]

When noncompliance issues are identified, they are first addressed within the project and resolved there if possible. Any noncompliance issues that cannot be resolved within the project are escalated to an appropriate level of management for resolution. [PA145.N107]

This process area primarily applies to evaluations of products and services, but it also applies to evaluations of nonproject activities and work products such as training activities. For these activities and work products, the term "project" should be appropriately interpreted. [PA145.N108]

Related Process Areas

Refer to the Project Planning process area for more information about identifying processes and associated work products that will be objectively evaluated. [PA145.R101]

Refer to the Verification process area for more information about satisfying specified requirements. [PA145.R102]

Specific and Generic Goals

SG 1 **Objectively Evaluate Processes and Work Products** [PA145.IG101]

Adherence of the performed process and associated work products and services to applicable process descriptions, standards, and procedures is objectively evaluated.

SG 2 **Provide Objective Insight** [PA145.IG102]

Noncompliance issues are objectively tracked and communicated, and resolution is ensured.

GG 2 **Institutionalize a Managed Process** [CL103.GL101]

The process is institutionalized as a managed process.

(The following goal is not required for maturity level 2, but required for maturity level 3 and above.)

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Objectively Evaluate Processes and Work Products [PA145.IG101]

SP 1.1	Objectively Evaluate Processes
SP 1.2	Objectively Evaluate Work Products and Services

SG 2 Provide Objective Insight [PA145.IG102]

SP 2.1	Communicate and Ensure Resolution of Noncompliance Issues
SP 2.2	Establish Records

GG 2 Institutionalize a Managed Process [CL103.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 2.2	(AB 1)	Plan the Process
GP 2.3	(AB 2)	Provide Resources
GP 2.4	(AB 3)	Assign Responsibility
GP 2.5	(AB 4)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

(The following goal is not required and its practices are not expected for a maturity level 2 rating, but are required and expected for a maturity level 3 rating and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 3.1 Establish a Defined Process

GP 3.2 Collect Improvement Information

Specific Practices by Goal

SG 1 Objectively Evaluate Processes and Work Products

Adherence of the performed process and associated work products and services to applicable process descriptions, standards, and procedures is objectively evaluated. *[PA145.IG101]*

SP 1.1 Objectively Evaluate Processes

Objectively evaluate the designated performed processes against the applicable process descriptions, standards, and procedures.
[PA145.IG101.SP101]

Objectivity in quality assurance evaluations is critical to the success of the project. A description of the quality assurance reporting chain and how it ensures objectivity should be defined. [PA145.IG101.SP101.N101]

Typical Work Products

1. Evaluation reports [PA145.IG101.SP101.W101]
2. Noncompliance reports [PA145.IG101.SP101.W102]
3. Corrective actions [PA145.IG101.SP101.W103]

Subpractices

1. Promote an environment (created as part of project management) that encourages employee participation in identifying and reporting quality issues. [PA145.IG101.SP101.SubP101]
2. Establish and maintain clearly stated criteria for the evaluations. [PA145.IG101.SP101.SubP102]

   The intent of this subpractice is to provide criteria, based on business needs, such as the following: [PA145.IG101.SP101.SubP102.N101]

   - What will be evaluated
   - When or how often a process will be evaluated
   - How the evaluation will be conducted
   - Who must be involved in the evaluation

3. Use the stated criteria to evaluate performed processes for adherence to process descriptions, standards, and procedures. [PA145.IG101.SP101.SubP103]

4. Identify each noncompliance found during the evaluation. [PA145.IG101.SP101.SubP104]

5. Identify lessons learned that could improve processes for future products and services. [PA145.IG101.SP101.SubP105]

SP 1.2 Objectively Evaluate Work Products and Services

Objectively evaluate the designated work products and services against the applicable process descriptions, standards, and procedures. *[PA145.IG101.SP102]*

Typical Work Products

1. Evaluation reports [PA145.IG101.SP102.W101]
2. Noncompliance reports [PA145.IG101.SP102.W102]
3. Corrective actions [PA145.IG101.SP102.W103]

Subpractices

1. Select work products to be evaluated, based on documented sampling criteria if sampling is used. [PA145.IG101.SP102.SubP101]
2. Establish and maintain clearly stated criteria for the evaluation of work products. [PA145.IG101.SP102.SubP102]

   The intent of this subpractice is to provide criteria, based on business needs, such as the following: [PA145.IG101.SP102.SubP102.N101]

   - What will be evaluated during the evaluation of a work product
   - When or how often a work product will be evaluated
   - How the evaluation will be conducted
   - Who must be involved in the evaluation

3. Use the stated criteria during the evaluations of work products. [PA145.IG101.SP102.SubP103]
4. Evaluate work products before they are delivered to the customer. [PA145.IG101.SP102.SubP104]
5. Evaluate work products at selected milestones in their development. [PA145.IG101.SP102.SubP105]
6. Perform in-progress or incremental evaluations of work products and services against process descriptions, standards, and procedures. [PA145.IG101.SP102.SubP106]

7. Identify each case of noncompliance found during the evaluations. [PA145.IG101.SP102.SubP107]

8. Identify lessons learned that could improve processes for future products and services. [PA145.IG101.SP102.SubP108]

SG 2 Provide Objective Insight

Noncompliance issues are objectively tracked and communicated, and resolution is ensured. *[PA145.IG102]*

SP 2.1 Communicate and Ensure Resolution of Noncompliance Issues

Communicate quality issues and ensure resolution of noncompliance issues with the staff and managers. *[PA145.IG102.SP101]*

Noncompliance issues are problems identified in evaluations that reflect a lack of adherence to applicable standards, process descriptions, or procedures. The status of noncompliance issues provides an indication of quality trends. Quality issues include noncompliance issues and results of trend analysis. [PA145.IG102.SP101.N101]

When local resolution of noncompliance issues cannot be obtained, use established escalation mechanisms to ensure that the appropriate level of management can resolve the issue. Track noncompliance issues to resolution. [PA145.IG102.SP101.N102]

Typical Work Products

1. Corrective action reports [PA145.IG102.SP101.W101]
2. Evaluation reports [PA145.IG102.SP101.W102]
3. Quality trends [PA145.IG102.SP101.W103]

Subpractices

1. Resolve each noncompliance with the appropriate members of the staff where possible. [PA145.IG102.SP101.SubP101]
2. Document noncompliance issues when they cannot be resolved within the project. [PA145.IG102.SP101.SubP102]

Examples of ways to resolve noncompliance within the project include the following: [PA145.IG102.SP101.SubP102.N101]

- Fixing the noncompliance
- Changing the process descriptions, standards, or procedures that were violated
- Obtaining a waiver to cover the noncompliance issue

3. Escalate noncompliance issues that cannot be resolved within the project to the appropriate level of management designated to receive and act on noncompliance issues. [PA145.IG102.SP101.SubP103]

4. Analyze the noncompliance issues to see if there are any quality trends that can be identified and addressed. [PA145.IG102.SP101.SubP104]

5. Ensure that relevant stakeholders are aware of the results of evaluations and the quality trends in a timely manner. [PA145.IG102.SP101.SubP105]

6. Periodically review open noncompliance issues and trends with the manager designated to receive and act on noncompliance issues. [PA145.IG102.SP101.SubP106]

7. Track noncompliance issues to resolution. [PA145.IG102.SP101.SubP107]

SP 2.2 Establish Records

Establish and maintain records of the quality assurance activities. *[PA145.IG102.SP102]*

Typical Work Products

1. Evaluation logs [PA145.IG102.SP102.W101]
2. Quality assurance reports [PA145.IG102.SP102.W102]
3. Status reports of corrective actions [PA145.IG102.SP102.W103]
4. Reports of quality trends [PA145.IG102.SP102.W104]

Subpractices

1. Record process and product quality assurance activities in sufficient detail such that status and results are known. [PA145.IG102.SP102.SubP101]
2. Revise the status and history of the quality assurance activities as necessary. [PA145.IG102.SP102.SubP102]

GG 2 Institutionalize a Managed Process [CL103.GL101]

The process is institutionalized as a managed process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the process and product quality assurance process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for objectively evaluating whether processes and associated work products adhere to the applicable process descriptions, standards, and procedures, and ensuring that noncompliance is addressed. [PA145.EL101]

This policy also establishes organizational expectations for process and product quality assurance being in place for all projects. Process and product quality assurance must possess sufficient independence from project management to provide objectivity in identifying and reporting noncompliance issues. [PA145.EL102]

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the plan for performing the process and product quality assurance process. *[GP104]*

Elaboration:

This plan for performing the process and product quality assurance process may be included in (or referenced by) the project plan, which is described in the Project Planning process area. [PA145.EL114]

GP 2.3 (AB 2) Provide Resources

Provide adequate resources for performing the process and product quality assurance process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Examples of resources provided include the following tools: [PA145.EL105]

- Evaluation tools
- Noncompliance tracking tool

GP 2.4 (AB 3) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the process and product quality assurance process. *[GP106]*

Elaboration:

To guard against subjectivity or bias, ensure that those people assigned responsibility and authority for process and product quality assurance can perform their evaluations with sufficient independence and objectivity. [PA145.EL115]

GP 2.5 (AB 4) Train People

Train the people performing or supporting the process and product quality assurance process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA145.EL106]

- Application domain
- Customer relations
- Process descriptions, standards, procedures, and methods for the project
- Quality assurance objectives, process descriptions, standards, procedures, methods, and tools

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the process and product quality assurance process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA145.EL111]

- Noncompliance reports
- Evaluation logs and reports

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the process and product quality assurance process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include the following: [PA145.EL113]

- Establishing criteria for the objective evaluations of processes and work products
- Evaluating processes and work products
- Resolving noncompliance issues
- Tracking noncompliance issues to closure

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the process and product quality assurance process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA145.EL108]

- Variance of objective process evaluations planned and performed
- Variance of objective work product evaluations planned and performed

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the process and product quality assurance process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA145.EL109]

- Objectively evaluating processes and work products
- Tracking and communicating noncompliance issues

Examples of work products reviewed include the following: [PA145.EL112]

- Noncompliance reports
- Evaluation logs and reports

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the process and product quality assurance process with higher level management and resolve issues. *[GP112]*

(The following goal is not required and its practices are not expected for a maturity level 2 rating, but are required for a maturity level 3 rating and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

GP 3.1 Establish a Defined Process

Establish and maintain the description of a defined process and product quality assurance process. *[GP114]*

GP 3.2 Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the process and product quality assurance process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

CONFIGURATION MANAGEMENT

Maturity Level 2

Purpose

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. [PA159]

Introductory Notes

The Configuration Management process area involves the following: [PA159.N101]

- Identifying the configuration of selected work products that compose the baselines at given points in time
- Controlling changes to configuration items
- Building or providing specifications to build work products from the configuration management system
- Maintaining the integrity of baselines
- Providing accurate status and current configuration data to developers, end users, and customers

The work products placed under configuration management include the products that are delivered to the customer, designated internal work products, acquired products, tools, and other items that are used in creating and describing these work products. See the definition of "configuration management" in Appendix C, the glossary. [PA159.N102]

Examples of work products that may be placed under configuration management include the following: [PA159.N109]

- Plans
- Process descriptions
- Requirements
- Design data
- Drawings
- Product specifications
- Code
- Compilers
- Product data files
- Product technical publications

Configuration management of work products may be performed at several levels of granularity. See the definition of "configuration item" in Appendix C, the glossary. Configuration items can be decomposed into configuration components and configuration units. Only the term "configuration item" is used in this process area. Therefore, in these practices, "configuration item" may be interpreted as "configuration component" or "configuration unit" as appropriate. [PA159.N103]

Baselines provide a stable basis for continuing evolution of configuration items. See the definition of "baseline" in Appendix C, the glossary. [PA159.N104]

An example of a baseline is an approved description of a product that includes internally consistent versions of requirements, requirement traceability matrices, design, discipline-specific items, and end-user documentation. [PA159.N110]

Baselines are added to the configuration management system as they are developed. Changes to baselines and the release of work products built from the configuration management system are systematically controlled and monitored via the configuration control, change management, and configuration auditing functions of configuration management. [PA159.N105]

This process area applies not only to configuration management on projects, but also to configuration management on organization work products such as standards, procedures, and reuse libraries. [PA159.N106]

Configuration management is focused on the rigorous control of the managerial and technical aspects of work products, including the delivered system. [PA159.N107]

This process area covers the practices for performing the configuration management function and is applicable to all work products that are placed under configuration management. [PA159.N108]

Related Process Areas

Refer to the Project Planning process area for information on developing plans and work breakdown structures, which may be useful for determining configuration items. [PA159.R101]

Refer to the Causal Analysis and Resolution process area for more information about both the method to use for analyzing the impact of change requests and the method to use when evaluating changes. [PA159.R102]

Refer to the Project Monitoring and Control process area for more information about performance analyses and corrective actions. [PA159.R103]

Specific and Generic Goals

SG 1 **Establish Baselines** [PA159.IG101]

Baselines of identified work products are established.

SG 2 **Track and Control Changes** [PA159.IG102]

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

SG 3 **Establish Integrity** [PA159.IG103]

Integrity of baselines is established and maintained.

GG 2 **Institutionalize a Managed Process** [CL103.GL101]

The process is institutionalized as a managed process.

(The following goal is not required for maturity level 2, but required for maturity level 3 and above.)

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Establish Baselines [PA159.IG101]

SP 1.1	Identify Configuration Items
SP 1.2	Establish a Configuration Management System
SP 1.3	Create or Release Baselines

SG 2 Track and Control Changes [PA159.IG102]

SP 2.1	Track Change Requests
SP 2.2	Control Configuration Items

SG 3 Establish Integrity [PA159.IG103]

SP 3.1	Establish Configuration Management Records
SP 3.2	Perform Configuration Audits

GG 2 Institutionalize a Managed Process [CL103.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 2.2	(AB 1)	Plan the Process
GP 2.3	(AB 2)	Provide Resources
GP 2.4	(AB 3)	Assign Responsibility
GP 2.5	(AB 4)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

(The following goal is not required and its practices are not expected for a maturity level 2 rating, but are required and expected for a maturity level 3 rating and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 3.1	Establish a Defined Process
GP 3.2	Collect Improvement Information

Specific Practices by Goal

SG 1 Establish Baselines

Baselines of identified work products are established. *[PA159.IG101]*

Specific practices to establish baselines are covered by this specific goal. The specific practices under the Track and Control Changes specific goal serve to maintain the baselines. The specific practices of the Establish Integrity specific goal document and audit the integrity of the baselines. [PA159.IG101.N101]

SP 1.1 Identify Configuration Items

Identify the configuration items, components, and related work products that will be placed under configuration management.

[PA159.IG101.SP101]

Configuration identification is the selection, creation, and specification of the following: [PA159.IG101.SP101.N101]

- Products that are delivered to the customer
- Designated internal work products
- Acquired products
- Tools
- Other items that are used in creating and describing these work products

Items under configuration management will include specifications and interface documents that define the requirements for the product. Other documents, such as test results, may also be included, depending on their criticality to defining the product. [PA159.IG101.SP101.N104]

A "configuration item" is an entity designated for configuration management, which may consist of multiple related work products that form a baseline. This logical grouping provides ease of identification and controlled access. The selection of work products for configuration management should be based on criteria established during planning. [PA159.IG101.SP101.N102]

> *For Systems Engineering*
>
> *In a system that includes both hardware and software, where software represents a small part of the system, all of the software may be designated as a single configuration item. In other cases, the software may be decomposed into multiple configuration items.* [PA159.IG101.SP101.N102.AMP101]

Configuration items can be decomposed into configuration components and configuration units. Only the term "configuration item" is used in this process area. In these practices, "configuration item" may be interpreted as "configuration component" or "configuration unit" as appropriate. For example, configuration items in the area of requirements management could vary from each individual requirement to a set of requirements. [PA159.IG101.SP101.N103]

Typical Work Products

1. Identified configuration items [PA159.IG101.SP101.W101]

Subpractices

1. Select the configuration items and the work products that compose them based on documented criteria. [PA159.IG101.SP101.SubP101]

Example criteria for selecting configuration items at the appropriate work product level include the following: [PA159.IG101.SP101.SubP101.N102]

- Work products that may be used by two or more groups
- Work products that are expected to change over time either because of errors or change of requirements
- Work products that are dependent on each other in that a change in one mandates a change in the others
- Work products that are critical for the project

Examples of work products that may be part of a configuration item include the following: [PA159.IG101.SP101.SubP101.N101]

- Process descriptions
- Requirements
- Design
- Test plans and procedures
- Test results
- Interface descriptions

For Software Engineering

Examples of software work products that may be part of a configuration item include the following: [PA159.IG101.SP101.SubP101.N101.AMP101]

- *Code/module*
- *Tools (e.g., compilers)*

2. Assign unique identifiers to configuration items. [PA159.IG101.SP101.SubP102]
3. Specify the important characteristics of each configuration item. [PA159.IG101.SP101.SubP103]

Example characteristics of configuration items include author, document or file type, and programming language for software code files. [PA159.IG101.SP101.SubP103.N101]

4. Specify when each configuration item is placed under configuration management. [PA159.IG101.SP101.SubP104]

Example criteria for determining when to place work products under configuration management include the following: [PA159.IG101.SP101.SubP104.N101]

- Stage of the project life cycle
- When the work product is ready for test
- Degree of control desired on the work product
- Cost and schedule limitations
- Customer requirements

5. Identify the owner responsible for each configuration item.
[PA159.IG101.SP101.SubP105]

SP 1.2 Establish a Configuration Management System

Establish and maintain a configuration management and change management system for controlling work products. *[PA159.IG101.SP102]*

A configuration management system includes the storage media, the procedures, and the tools for accessing the configuration system.
[PA159.IG101.SP102.N101]

A change management system includes the storage media, the procedures, and tools for recording and accessing change requests.
[PA159.IG101.SP102.N102]

Typical Work Products

1. Configuration management system with controlled work products
[PA159.IG101.SP102.W101]
2. Configuration management system access control procedures
[PA159.IG101.SP102.W102]
3. Change request database [PA159.IG101.SP102.W103]

Subpractices

1. Establish a mechanism to manage multiple control levels of configuration management. [PA159.IG101.SP102.SubP101]

Examples of situations leading to multiple levels of control include the following:
[PA159.IG101.SP102.SubP101.N101]

- Differences in the levels of control needed at different times in the project life cycle (e.g., tighter control as product matures)
- Differences in the levels of control needed for different types of systems (e.g., software-only systems versus systems that include hardware and software)
- Differences in the levels of control needed to satisfy privacy and security requirements for the configuration items

2. Store and retrieve configuration items in the configuration management system. [PA159.IG101.SP102.SubP102]

   Examples of configuration management systems include the following: [PA159.IG101.SP102.SubP102.N101]

   - Dynamic (or developer's) systems contain components currently being created or revised. They are in the developer's workspace and are controlled by the developer. Configuration items in a dynamic system are under version control.
   - Master (or controlled) systems contain current baselines and changes to them. Configuration items in a master system are under full configuration management as described in this process area.
   - Static systems contain archives of various baselines released for use. Static systems are under full configuration management as described in this process area.

3. Share and transfer configuration items between control levels within the configuration management system. [PA159.IG101.SP102.SubP103]

4. Store and recover archived versions of configuration items. [PA159.IG101.SP102.SubP104]

5. Store, update, and retrieve configuration management records. [PA159.IG101.SP102.SubP105]

6. Create configuration management reports from the configuration management system. [PA159.IG101.SP102.SubP106]

7. Preserve the contents of the configuration management system. [PA159.IG101.SP102.SubP107]

   Examples of preservation functions of the configuration management system include the following: [PA159.IG101.SP102.SubP107.N101]

   - Backups and restoration of configuration management files
   - Archiving of configuration management files
   - Recovery from configuration management errors

8. Revise the configuration management structure as necessary. [PA159.IG101.SP102.SubP108]

SP 1.3 Create or Release Baselines

Create or release baselines for internal use and for delivery to the customer. *[PA159.IG101.SP103]*

A baseline is a set of specifications or work products that has been formally reviewed and agreed upon, that thereafter serves as the basis for further development, and that can be changed only through change control procedures. A baseline represents the assignment of an identifier to a configuration item and its associated entities.

[PA159.IG101.SP103.N101]

For Systems Engineering

Release of a baseline involves approving a set of configuration data for the agreed-upon set of configuration items from the configuration management system and releasing the baseline for further development. Multiple baselines may be used to define an evolving product during its development cycle. One common set includes the system-level requirements, system-element-level design requirements, and the product definition at the end of development/beginning of production. These are referred to as the "functional baseline," "allocated baseline," and "product baseline." [PA159.IG101.SP103.N101.AMP101]

For Software Engineering

A set of requirements, design, source code files and the associated executable code, build files, and user documentation (associated entities) that have been assigned a unique identifier can be considered to be a baseline. Release of a baseline constitutes retrieval of source code files (configuration items) from the configuration management system and generating the executable files. A baseline that is delivered to a customer is typically called a "release" whereas a baseline for an internal use is typically called a "build."

[PA159.IG101.SP103.N101.AMP102]

Typical Work Products

1. Baselines [PA159.IG101.SP103.W101]
2. Description of baselines [PA159.IG101.SP103.W102]

Subpractices

1. Obtain authorization from the configuration control board (CCB) before creating or releasing baselines of configuration items.

   [PA159.IG101.SP103.SubP101]

2. Create or release baselines only from configuration items in the configuration management system. [PA159.IG101.SP103.SubP102]

   For Systems Engineering

   Ensure that the configuration items are built to the correct drawing. [PA159.IG101.SP103.SubP102.AMP101]

3. Document the set of configuration items that are contained in a baseline. [PA159.IG101.SP103.SubP103]

4. Make the current set of baselines readily available.
[PA159.IG101.SP103.SubP104]

SG 2 Track and Control Changes

Changes to the work products under configuration management are tracked and controlled. *[PA159.IG102]*

The specific practices under this specific goal serve to maintain the baselines after they are established by the specific practices under the Establish Baselines specific goal. [PA159.IG102.N101]

SP 2.1 Track Change Requests

Track change requests for the configuration items. *[PA159.IG102.SP101]*

Change requests address not only new or changed requirements, but also failures and defects in the work products. [PA159.IG102.SP101.N101]

Change requests are analyzed to determine the impact that the change will have on the work product, related work products, and schedule and cost. [PA159.IG102.SP101.N102]

Typical Work Products

1. Change requests [PA159.IG102.SP101.W101]

Subpractices

1. Initiate and record change requests in the change request database. [PA159.IG102.SP101.SubP101]
2. Analyze the impact of changes and fixes proposed in the change requests. [PA159.IG102.SP101.SubP102]

   Changes are evaluated through activities that ensure that they are consistent with all technical and project requirements. [PA159.IG102.SP101.SubP102.N101]

   Changes are evaluated for their impact beyond immediate project or contract requirements. Changes to an item used in multiple products can resolve an immediate issue while causing a problem in other applications.
   [PA159.IG102.SP101.SubP102.N102]
3. Review change requests that will be addressed in the next baseline with those who will be affected by the changes and get their agreement. [PA159.IG102.SP101.SubP103]

Conduct the change request review with appropriate participants. Record the disposition of each change request and the rationale for the decision, including success criteria, a brief action plan if appropriate, and needs met or unmet by the change. Perform the actions required in the disposition, and report the results to relevant stakeholders. [PA159.IG102.SP101.SubP103.N101]

4. Track the status of change requests to closure. [PA159.IG102.SP101.SubP104]

   Change requests brought into the system need to be handled in a proficient and timely manner. Once a change request has been processed, it is critical to close the request with the appropriate approved action as soon as it is practical. Actions left open result in larger than necessary status lists, which in turn result in added costs and confusion. [PA159.IG102.SP101.SubP104.N101]

SP 2.2 Control Configuration Items

Control changes to the configuration items. *[PA159.IG102.SP102]*

Control is maintained over the configuration of the work product baseline. This control includes tracking the configuration of each of the configuration items, approving a new configuration if necessary, and updating the baseline. [PA159.IG102.SP102.N101]

Typical Work Products

1. Revision history of configuration items [PA159.IG102.SP102.W101]
2. Archives of the baselines [PA159.IG102.SP102.W102]

Subpractices

1. Control changes to configuration items throughout the life of the product. [PA159.IG102.SP102.SubP101]
2. Obtain appropriate authorization before changed configuration items are entered into the configuration management system. [PA159.IG102.SP102.SubP102]

   For example, authorization may come from the CCB, the project manager, or the customer. [PA159.IG102.SP102.SubP102.N101]

3. Check in and check out configuration items from the configuration management system for incorporation of changes in a manner that maintains the correctness and integrity of the configuration items. [PA159.IG102.SP102.SubP103]

Examples of check-in and check-out steps include the following:
[PA159.IG102.SP102.SubP103.N101]

- Confirming that the revisions are authorized
- Updating the configuration items
- Archiving the replaced baseline and retrieving the new baseline

4. Perform reviews to ensure that changes have not caused unintended effects on the baselines (e.g., ensure that the changes have not compromised the safety and/or security of the system). [PA159.IG102.SP102.SubP104]

5. Record changes to configuration items and the reasons for the changes as appropriate. [PA159.IG102.SP102.SubP105]

   If a proposed change to the work product is accepted, a schedule is identified for incorporating the change into the work product and other affected areas. [PA159.IG102.SP102.SubP105.N101]

   Configuration control mechanisms can be tailored to categories of changes. For example, the approval considerations could be less stringent for component changes that do not affect other components. [PA159.IG102.SP102.SubP105.N102]

   Changed configuration items are released after review and approval of configuration changes. Changes are not official until they are released. [PA159.IG102.SP102.SubP105.N103]

SG 3 Establish Integrity

Integrity of baselines is established and maintained. *[PA159.IG103]*

The integrity of the baselines, established by processes associated with the Establish Baselines specific goal, and maintained by processes associated with the Track and Control Changes specific goal, is provided by the specific practices under this specific goal. [PA159.IG103.N101]

SP 3.1 Establish Configuration Management Records

Establish and maintain records describing configuration items.
[PA159.IG103.SP101]

Typical Work Products

1. Revision history of configuration items [PA159.IG103.SP101.W101]
2. Change log [PA159.IG103.SP101.W102]
3. Copy of the change requests [PA159.IG103.SP101.W103]
4. Status of configuration items [PA159.IG103.SP101.W104]

5. Differences between baselines [PA159.IG103.SP101.W105]

Subpractices

1. Record configuration management actions in sufficient detail so the content and status of each configuration item is known and previous versions can be recovered. [PA159.IG103.SP101.SubP101]

2. Ensure that relevant stakeholders have access to and knowledge of the configuration status of the configuration items. [PA159.IG103.SP101.SubP102]

> Examples of activities for communicating configuration status include the following: [PA159.IG103.SP101.SubP102.N101]
>
> - Providing access permissions to authorized end users
> - Making baseline copies readily available to authorized end users

3. Specify the latest version of the baselines. [PA159.IG103.SP101.SubP103]

4. Identify the version of configuration items that constitute a particular baseline. [PA159.IG103.SP101.SubP104]

5. Describe the differences between successive baselines. [PA159.IG103.SP101.SubP105]

6. Revise the status and history (i.e., changes and other actions) of each configuration item as necessary. [PA159.IG103.SP101.SubP106]

SP 3.2 Perform Configuration Audits

Perform configuration audits to maintain integrity of the configuration baselines. *[PA159.IG103.SP102]*

Audit configuration management activities and processes to confirm that the resulting baselines and documentation are accurate, and record the audit results as appropriate. [PA159.IG103.SP102.N101]

Typical Work Products

1. Configuration audit results [PA159.IG103.SP102.W101]

2. Action items [PA159.IG103.SP102.W102]

Subpractices

1. Assess the integrity of the baselines. [PA159.IG103.SP102.SubP101]

2. Confirm that the configuration records correctly identify the configuration of the configuration items. [PA159.IG103.SP102.SubP102]

3. Review the structure and integrity of the items in the configuration management system. [PA159.IG103.SP102.SubP103]

4. Confirm the completeness and correctness of the items in the configuration management system. [PA159.IG103.SP102.SubP104]

   Completeness and correctness of the content is based on the requirements as stated in the plan and the disposition of approved change requests.
   [PA159.IG103.SP102.SubP104.N101]

5. Confirm compliance with applicable configuration management standards and procedures. [PA159.IG103.SP102.SubP105]

6. Track action items from the audit to closure. [PA159.IG103.SP102.SubP106]

GG 2 Institutionalize a Managed Process [CL103.GL101]

The process is institutionalized as a managed process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the configuration management process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for establishing and maintaining baselines, tracking and controlling changes to the work products (under configuration management), and establishing and maintaining integrity of the baselines. [PA159.EL101]

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the plan for performing the configuration management process. *[GP104]*

Elaboration:

This plan for performing the configuration management process can be included in (or referenced by) the project plan, which is described in the Project Planning process area. [PA159.EL112]

GP 2.3 (AB 2) Provide Resources

Provide adequate resources for performing the configuration management process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Examples of resources provided include the following tools: [PA159.EL104]

- Configuration management tools
- Data management tools
- Archiving and reproduction tools
- Database programs

GP 2.4 (AB 3) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the configuration management process. *[GP106]*

GP 2.5 (AB 4) Train People

Train the people performing or supporting the configuration management process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA159.EL105]

- Roles, responsibilities, and authority of the configuration management staff
- Configuration management standards, procedures, and methods
- Configuration library system

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the configuration management process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA159.EL106]

- Access lists
- Change status reports
- Change request database
- CCB meeting minutes
- Archived baselines

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the configuration management process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include the following: [PA159.EL111]

- Establishing baselines
- Reviewing configuration management system reports and resolving issues
- Assessing the impact of changes for the configuration items
- Performing configuration audits
- Reviewing the results of configuration management audits

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the configuration management process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA159.EL108]

- Number of changes to configuration items
- Number of configuration audits conducted

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the configuration management process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA159.EL109]

- Establishing baselines
- Tracking and controlling changes
- Establishing and maintaining integrity of baselines

Examples of work products reviewed include the following: [PA159.EL110]

- Archives of the baselines
- Change request database

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the configuration management process with higher level management and resolve issues. *[GP112]*

(The following goal is not required and its practices are not expected for a maturity level 2 rating, but are required for a maturity level 3 rating and above.)

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

GP 3.1 Establish a Defined Process

Establish and maintain the description of a defined configuration management process. *[GP114]*

GP 3.2 Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the configuration management process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

MATURITY LEVEL 3: DEFINED

The following section contains all of the process areas that belong to maturity level 3. The maturity level 3 process areas of CMMI are as follows: [FM110.T101]

- Requirements Development
- Technical Solution
- Product Integration
- Verification
- Validation
- Organizational Process Focus
- Organizational Process Definition
- Organizational Training
- Integrated Project Management for IPPD
- Risk Management
- Integrated Teaming
- Decision Analysis and Resolution
- Organizational Environment for Integration

See Chapter 2 for more information about CMMI maturity levels. [FM110.T105]

REQUIREMENTS DEVELOPMENT

Maturity Level 3

Purpose

The purpose of Requirements Development is to produce and analyze customer, product, and product-component requirements. [PA157]

Introductory Notes

This process area describes three types of requirements: customer requirements, product requirements, and product-component requirements. Taken together, these requirements address the needs of relevant stakeholders, including those pertinent to various product life-cycle phases (e.g., acceptance testing criteria) and product attributes (e.g., safety, reliability, maintainability). Requirements also address constraints caused by the selection of design solutions (e.g., integration of commercial off-the-shelf products). [PA157.N101]

Requirements are the basis for design. The development of requirements includes the following activities: [PA157.N102]

- Elicitation, analysis, validation, and communication of customer needs, expectations, and constraints to obtain customer requirements that constitute an understanding of what will satisfy stakeholders
- Collection and coordination of stakeholder needs
- Development of the life-cycle requirements of the product
- Establishment of the customer requirements
- Establishment of initial product and product-component requirements consistent with customer requirements

This process area addresses all customer requirements rather than only product-level requirements because the customer may also provide specific design requirements. [PA157.N103]

Customer requirements are further refined into product and product-component requirements. In addition to customer requirements, product and product-component requirements are derived from the selected design solutions. [PA157.N104]

Requirements are identified and refined throughout the phases of the product life cycle. Design decisions, subsequent corrective actions, and feedback during each phase of the product's life cycle are analyzed for impact on derived and allocated requirements. [PA157.N105]

The Requirements Development process area includes three specific goals. The Develop Customer Requirements specific goal addresses defining a set of customer requirements to use in the development of product requirements. The Develop Product Requirements specific goal addresses defining a set of product or product-component requirements to use in the design of products and product components. The Analyze and Validate Requirements specific goal addresses the necessary analysis of customer, product, and product-component requirements to define, derive, and understand the requirements. The specific practices of the third specific goal are intended to assist the specific practices in the first two specific goals. The processes associated with the Requirements Development process area and those associated with the Technical Solution process area may interact recursively with one another. [PA157.N111]

Analyses are used to understand, define, and select the requirements at all levels from competing alternatives. These analyses include the following: [PA157.N106]

- Analysis of needs and requirements for each product life-cycle phase, including needs of relevant stakeholders, the operational environment, and factors that reflect overall customer and end-user expectations and satisfaction, such as safety, security, and affordability
- Development of an operational concept
- Definition of the required functionality

The definition of functionality, also referred to as "functional analysis," is not the same as structured analysis in software development and does not presume a functionally oriented software design. In object-oriented software design, it relates to defining the services. The definition of functions, their logical groupings, and their association with requirements is referred to as a "functional architecture." [PA157.N107]

Analyses occur recursively at successively more detailed layers of a product's architecture until sufficient detail is available to enable detailed design, acquisition, and testing of the product to proceed. As a result of the analysis of requirements and the operational concept (including functionality, support, maintenance, and disposal), the manufacturing or production concept produces more derived requirements, including consideration of the following: [PA157.N108]

- Constraints of various types
- Technological limitations

- Cost and cost drivers
- Time constraints and schedule drivers
- Risks
- Consideration of issues implied but not explicitly stated by the customer or end user
- Factors introduced by the developer's unique business considerations, regulations, and laws

A hierarchy of logical entities (functions and subfunctions, object classes and subclasses) is established through iteration with the evolving operational concept. Requirements are refined, derived, and allocated to these logical entities. Requirements and logical entities are allocated to products, product components, people, associated processes, or services. [PA157.N109]

Involvement of relevant stakeholders in both requirements development and analysis gives them visibility into the evolution of requirements. This activity continually assures them that the requirements are being properly defined. [PA157.N110]

Related Process Areas

Refer to the Requirements Management process area for more information about managing customer and product requirements, obtaining agreement with the requirements provider, obtaining commitments with those implementing the requirements, and maintaining traceability. [PA157.R101]

Refer to the Technical Solution process area for more information about how the outputs of the requirements development processes are used, and the development of alternative solutions and designs used in refining and deriving requirements. [PA157.R102]

Refer to the Product Integration process area for more information about interface requirements and interface management. [PA157.R103]

Refer to the Verification process area for more information about verifying that the resulting product meets the requirements. [PA157.R104]

Refer to the Validation process area for more information about how the product built will be validated against the customer needs. [PA157.R105]

Refer to the Risk Management process area for more information about identifying and managing risks that are related to requirements. [PA157.R106]

Refer to the Configuration Management process area for information about ensuring that key work products are controlled and managed.

[PA157.R107]

Specific and Generic Goals

SG 1 **Develop Customer Requirements** [PA157.IG101]

Stakeholder needs, expectations, constraints, and interfaces are collected and translated into customer requirements.

SG 2 **Develop Product Requirements** [PA157.IG103]

Customer requirements are refined and elaborated to develop product and product-component requirements.

SG 3 **Analyze and Validate Requirements** [PA157.IG102]

The requirements are analyzed and validated, and a definition of required functionality is developed.

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Develop Customer Requirements [PA157.IG101]

- SP 1.1 Elicit Needs
- SP 1.2 Develop the Customer Requirements

SG 2 Develop Product Requirements [PA157.IG103]

- SP 2.1 Establish Product and Product-Component Requirements
- SP 2.2 Allocate Product-Component Requirements
- SP 2.3 Identify Interface Requirements

SG 3 Analyze and Validate Requirements [PA157.IG102]

- SP 3.1 Establish Operational Concepts and Scenarios
- SP 3.2 Establish a Definition of Required Functionality
- SP 3.3 Analyze Requirements
- SP 3.4 Analyze Requirements to Achieve Balance
- SP 3.5 Validate Requirements with Comprehensive Methods

GG 3 Institutionalize a Defined Process [CL104.GL101]

- GP 2.1 (CO 1) Establish an Organizational Policy
- GP 3.1 (AB 1) Establish a Defined Process
- GP 2.2 (AB 2) Plan the Process
- GP 2.3 (AB 3) Provide Resources

GP 2.4	(AB 4)	Assign Responsibility
GP 2.5	(AB 5)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 3.2	(DI 4)	Collect Improvement Information
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

Specific Practices by Goal

SG 1 Develop Customer Requirements

Stakeholder needs, expectations, constraints, and interfaces are collected and translated into customer requirements. *[PA157.IG101]*

The needs of stakeholders (e.g., customers, end users, suppliers, builders, and testers) are the basis for determining customer requirements. The stakeholder needs, expectations, constraints, interfaces, operational concepts, and product concepts are analyzed, harmonized, refined, and elaborated for translation into a set of customer requirements. [PA157.IG101.N101]

Frequently, stakeholder needs, expectations, constraints, and interfaces are poorly identified or conflicting. Since stakeholder needs, expectations, constraints, and limitations should be clearly identified and understood, an iterative process is used throughout the life of the project to accomplish this objective. To facilitate the required interaction, a surrogate for the end user or customer is frequently involved to represent their needs and help resolve conflicts. The customer relations or marketing part of the organization as well as members of the development team from disciplines such as human engineering or support can be used as surrogates. Environmental, legal, and other constraints should be considered when creating and resolving the set of customer requirements. [PA157.IG101.N102]

SP 1.1 Elicit Needs

Elicit stakeholder needs, expectations, constraints, and interfaces for all phases of the product life cycle. *[PA157.IG101.SP102]*

Eliciting goes beyond collecting requirements by proactively identifying additional requirements not explicitly provided by customers. Additional requirements should address the various product life-cycle activities and their impact on the product. [PA157.IG101.SP102.N102]

Examples of techniques to elicit needs include the following: [PA157.IG101.SP102.N103]

- Technology demonstrations
- Interface control working groups
- Technical control working groups
- Interim project reviews
- Questionnaires, interviews, and operational scenarios obtained from end users
- Operational walkthroughs and end-user task analysis
- Prototypes and models
- Brainstorming
- Quality Function Deployment
- Market surveys
- Beta testing
- Extraction from sources such as documents, standards, or specifications
- Observation of existing products, environments, and workflow patterns
- Use cases
- Business case analysis
- Reverse engineering (for legacy products)

Subpractices

1. Engage relevant stakeholders using methods for eliciting needs, expectations, constraints, and external interfaces.
   [PA157.IG101.SP102.SubP101]

The following specific practice appears in the continuous representation as SP 1.1-1, but is subsumed in the staged representation by SP 1.1, Elicit Needs. The specific practice is presented here in gray only as informative material.

SP 1.1-1 Collect Stakeholder Needs

Identify and collect stakeholder needs, expectations, constraints, and interfaces for all phases of the product life cycle. [PA157.IG101.SP101]

The basic activity addresses the receipt of requirements that a customer provides to define what is needed or desired. These requirements may or may not be stated in technical terms. They should address the various product life-cycle activities and their impact on the product. [PA157.IG101.SP101.N101]

SP 1.2 Develop the Customer Requirements

Transform stakeholder needs, expectations, constraints, and interfaces into customer requirements. *[PA157.IG101.SP103]*

For Integrated Product and Process Development

Relevant stakeholders representing all phases of the product's life cycle should include business as well as technical functions. In this way, concepts for all product-related life-cycle processes are considered concurrently with the concepts for the products. Customer requirements result from informed decisions on the business as well as technical effects of their requirements. *[PA157.IG101.SP103.AMP101]*

The various inputs from the customer must be consolidated, missing information must be obtained, and conflicts must be resolved in documenting the recognized set of customer requirements. The customer requirements may include needs, expectations, and constraints with regard to verification and validation. [PA157.IG101.SP103.N101]

Typical Work Products

1. Customer requirements [PA157.IG101.SP103.W101]
2. Customer constraints on the conduct of verification [PA157.IG101.SP103.W102]
3. Customer constraints on the conduct of validation [PA157.IG101.SP103.W103]

Subpractices

1. Translate the stakeholder needs, expectations, constraints, and interfaces into documented customer requirements. [PA157.IG101.SP103.SubP101]
2. Define constraints for verification and validation. [PA157.IG101.SP103.SubP102]

SG 2 Develop Product Requirements

Customer requirements are refined and elaborated to develop product and product-component requirements. *[PA157.IG103]*

Customer requirements are analyzed in conjunction with the development of the operational concept to derive more detailed and precise sets of requirements called "product and product-component requirements." Product and product-component requirements address the needs associated with each product life-cycle phase. Derived requirements arise from constraints, consideration of issues implied but not explicitly stated in the customer requirements baseline, and factors introduced by the selected architecture, the design, and the developer's unique business considerations. The requirements are reexamined with each successive, lower level set of requirements and functional architecture, and the preferred product concept is refined. [PA157.IG103.N101]

The requirements are allocated to product functions and product components including objects, people, and processes. The traceability of requirements to functions, objects, tests, issues, or other entities is documented. The allocated requirements and functions are the basis for the synthesis of the technical solution. As internal components are developed, additional interfaces are defined and interface requirements established. [PA157.IG103.N102]

Refer to the Maintain Bidirectional Traceability of Requirements specific practice of the Requirements Management process area for more information about maintaining bidirectional traceability. *[PA157.IG103.N102.R101]*

SP 2.1 Establish Product and Product-Component Requirements

Establish and maintain product and product-component requirements, which are based on the customer requirements.

[PA157.IG103.SP101]

The customer requirements may be expressed in the customer's terms and may be nontechnical descriptions. The product requirements are the expression of these requirements in technical terms that can be used for design decisions. An example of this translation is found in the first House of Quality Functional Deployment, which maps customer desires into technical parameters. For instance, "solid sounding door" might be mapped to size, weight, fit, dampening, and resonant frequencies. [PA157.IG103.SP101.N101]

Product and product-component requirements address the satisfaction of customer, business, and project objectives and associated attributes, such as effectiveness and affordability. [PA157.IG103.SP101.N104]

Design constraints include specifications on product components that are derived from design decisions, rather than higher level requirements. [PA157.IG103.SP101.N102]

For Software Engineering

For example, application components that must interface with an off-the-shelf database component must comply with interface requirements imposed by the selected database. Such product-component requirements are generally not traceable to higher level requirements.
[PA157.IG103.SP101.N102.AMP101]

Derived requirements also address the cost and performance of other life-cycle phases (e.g., production, operations, and disposal) to the extent compatible with business objectives. [PA157.IG103.SP101.N103]

The modification of requirements due to approved requirement changes is covered by the "maintain" function of this specific practice; whereas, the administration of requirement changes is covered by the Requirements Management process area. [PA157.IG103.SP101.N105]

Refer to the Requirements Management process area for more information about managing changes to requirements.
[PA157.IG103.SP101.N105.R101]

Typical Work Products

1. Derived requirements [PA157.IG103.SP101.W101]
2. Product requirements [PA157.IG103.SP101.W102]
3. Product-component requirements [PA157.IG103.SP101.W103]

Subpractices

1. Develop requirements in technical terms necessary for product and product-component design. [PA157.IG103.SP101.SubP101]

   Develop architecture requirements addressing critical product qualities and performance necessary for product architecture design. [PA157.IG103.SP101.SubP101.N101]

2. Derive requirements that result from design decisions.
   [PA157.IG103.SP101.SubP102]

   Refer to the Technical Solution process area for more information about developing the solutions that generate additional derived requirements. *[PA157.IG103.SP101.SubP102.R101]*

   Selection of a technology brings with it additional requirements. For instance, use of electronics requires additional technology-specific requirements such as electromagnetic interference limits. [PA157.IG103.SP101.SubP102.N101]

3. Establish and maintain relationships between requirements for consideration during change management and requirements allocation. [PA157.IG103.SP101.SubP103]

Refer to the Requirements Management process area for more information about maintaining requirements traceability.

[PA157.IG103.SP101.SubP103.R101]

Relationships between requirements can aid in evaluating the impact of changes.

[PA157.IG103.SP101.SubP103.N101]

SP 2.2 Allocate Product-Component Requirements

Allocate the requirements for each product component.

[PA157.IG103.SP102]

Refer to the Technical Solution process area for more information about allocation of requirements to products and product components. This specific practice provides information for defining the allocation of requirements but must interact with the specific practices in the Technical Solution process area to establish solutions to which the requirements are allocated. *[PA157.IG103.SP102.R101]*

The requirements for product components of the defined solution include allocation of product performance; design constraints; and fit, form, and function to meet requirements and facilitate production. In cases where a higher level requirement specifies performance that will be the responsibility of two or more product components, the performance must be partitioned for unique allocation to each product component as a derived requirement. [PA157.IG103.SP102.N101]

Typical Work Products

1. Requirement allocation sheets [PA157.IG103.SP102.W101]
2. Provisional requirement allocations [PA157.IG103.SP102.W102]
3. Design constraints [PA157.IG103.SP102.W103]
4. Derived requirements [PA157.IG103.SP102.W104]
5. Relationships among derived requirements [PA157.IG103.SP102.W105]

Subpractices

1. Allocate requirements to functions. [PA157.IG103.SP102.SubP101]
2. Allocate requirements to product components. [PA157.IG103.SP102.SubP102]
3. Allocate design constraints to product components.
   [PA157.IG103.SP102.SubP103]
4. Document relationships among allocated requirements.
   [PA157.IG103.SP102.SubP104]

   Relationships include dependencies in which a change in one requirement may affect other requirements. [PA157.IG103.SP102.SubP104.N101]

SP 2.3 Identify Interface Requirements

Identify interface requirements. *[PA157.IG103.SP103]*

Interfaces between functions (or between objects) are identified. Functional interfaces may drive the development of alternative solutions described in the Technical Solution process area. [PA157.IG103.SP103.N101]

Refer to the Product Integration process area for more information about the management of interfaces and the integration of products and product components. *[PA157.IG103.SP103.N101.R101]*

Interface requirements between products or product components identified in the product architecture are defined. They are controlled as part of product and product-component integration and are an integral part of the architecture definition. [PA157.IG103.SP103.N102]

Typical Work Products

1. Interface requirements [PA157.IG103.SP103.W101]

Subpractices

1. Identify interfaces both external to the product and internal to the product (i.e., between functional partitions or objects).
   [PA157.IG103.SP103.SubP101]

   As the design progresses, the product architecture will be altered by technical solution processes, creating new interfaces between product components and components external to the product. [PA157.IG103.SP103.SubP101.N101]

   Interfaces with product-related life-cycle processes should also be identified.
   [PA157.IG103.SP103.SubP101.N102]

   > Examples of these interfaces include interfaces with test equipment, transportation systems, support systems, and manufacturing facilities.
   > [PA157.IG103.SP103.SubP101.N103]

2. Develop the requirements for the identified interfaces.
   [PA157.IG103.SP103.SubP102]

   Refer to the Technical Solution process area for more information about generating new interfaces during the design process.
   [PA157.IG103.SP103.SubP102.R101]

   Requirements for interfaces are defined in terms of origination, destination, stimulus, data characteristics for software, and electrical and mechanical characteristics for hardware. [PA157.IG103.SP103.SubP102.N102]

SG 3 Analyze and Validate Requirements

The requirements are analyzed and validated, and a definition of required functionality is developed. *[PA157.IG102]*

The specific practices of the Analyze and Validate Requirements specific goal support the development of the requirements in both the Develop Customer Requirements specific goal and the Develop Product Requirements specific goal. The specific practices associated with this specific goal cover analyzing and validating the requirements with respect to the user's intended environment. [PA157.IG102.N104]

Analyses are performed to determine what impact the intended operational environment will have on the ability to satisfy the stakeholders' needs, expectations, constraints, and interfaces. Considerations such as feasibility, mission needs, cost constraints, potential market size, and acquisition strategy must all be taken into account, depending on the product context. A definition of required functionality is also established. All specified usage modes for the product are considered, and a timeline analysis is generated for time-critical sequencing of functions. [PA157.IG102.N101]

The objectives of the analyses are to determine candidate requirements for product concepts that will satisfy stakeholder needs, expectations, and constraints; and then translate these concepts into requirements. In parallel with this activity, the parameters that will be used to evaluate the effectiveness of the product are determined based on customer input and the preliminary product concept. [PA157.IG102.N102]

Requirements are validated to increase the probability that the resulting product will perform as intended in the use environment. [PA157.IG102.N103]

SP 3.1 Establish Operational Concepts and Scenarios

Establish and maintain operational concepts and associated scenarios. *[PA157.IG102.SP101]*

Refer to the Technical Solution process area for more information about detailed development of operational concepts that are dependent on the selected designs. *[PA157.IG102.SP101.R101]*

A scenario is a sequence of events that might occur in the use of the product, which is used to make explicit some of the needs of the stakeholders. In contrast, an operational concept for a product usually depends on both the design solution and the scenario. For example, the operational concept for a satellite-based communications product is quite different from one based on landlines. Since the alternative solutions have not usually been defined when preparing the initial operational concepts, conceptual solutions are developed for use when analyzing the requirements. The operational concepts are refined as solution decisions are made and lower level detailed requirements are developed. [PA157.IG102.SP101.N101]

Just as a design decision for a product may become a requirement for product components, the operational concept may become the scenarios (requirements) for product components. [PA157.IG102.SP101.N102]

The scenarios may include operational sequences, provided those sequences are an expression of customer requirements rather than operational concepts. [PA157.IG102.SP101.N103]

Typical Work Products

1. Operational concept [PA157.IG102.SP101.W101]
2. Product installation, operational, maintenance, and support concepts [PA157.IG102.SP101.W102]
3. Disposal concepts [PA157.IG102.SP101.W103]
4. Use cases [PA157.IG102.SP101.W104]
5. Timeline scenarios [PA157.IG102.SP101.W105]
6. New requirements [PA157.IG102.SP101.W106]

Subpractices

1. Develop operational concepts and scenarios that include functionality, performance, maintenance, support, and disposal as appropriate. [PA157.IG102.SP101.SubP101]

   Identify and develop scenarios, consistent with the level of detail in the stakeholder needs, expectations, and constraints, in which the proposed product is expected to operate. [PA157.IG102.SP101.SubP101.N101]

2. Define the environment the product will operate in, including boundaries and constraints. [PA157.IG102.SP101.SubP102]
3. Review operational concepts and scenarios to refine and discover requirements. [PA157.IG102.SP101.SubP103]

Operational concept and scenario development is an iterative process. The reviews should be held periodically to ensure that they agree with the requirements. The review may be in the form of a walkthrough.

[PA157.IG102.SP101.SubP103.N101]

4. Develop a detailed operational concept, as products and product components are selected, that defines the interaction of the product, the end user, and the environment, and that satisfies the operational, maintenance, support, and disposal needs.

[PA157.IG102.SP101.SubP104]

SP 3.2 Establish a Definition of Required Functionality

Establish and maintain a definition of required functionality.

[PA157.IG102.SP102]

The definition of functionality, also referred to as "functional analysis," is the description of what the product is intended to do. The definition of functionality can include actions, sequence, inputs, outputs, or other information that communicates the manner in which the product will be used. [PA157.IG102.SP102.N101]

Functional analysis is not the same as structured analysis in software development and does not presume a functionally oriented software design. In object-oriented software design, it relates to defining the services. The definition of functions, their logical groupings, and their association with requirements is referred to as a functional architecture. See the definition of "functional architecture" in Appendix C, the glossary. [PA157.IG102.SP102.N102]

Typical Work Products

1. Functional architecture [PA157.IG102.SP102.W101]
2. Activity diagrams and use cases [PA157.IG102.SP102.W102]
3. Object-oriented analysis with services identified [PA157.IG102.SP102.W103]

Subpractices

1. Analyze and quantify functionality required by end users.

   [PA157.IG102.SP102.SubP101]
2. Analyze requirements to identify logical or functional partitions (e.g., subfunctions). [PA157.IG102.SP102.SubP102]
3. Partition requirements into groups, based on established criteria (e.g., similar functionality, performance, or coupling), to facilitate and focus the requirements analysis. [PA157.IG102.SP102.SubP103]

4. Consider the sequencing of time-critical functions both initially and subsequently during product-component development. [PA157.IG102.SP102.SubP104]

5. Allocate customer requirements to functional partitions, objects, people, or support elements to support the synthesis of solutions. [PA157.IG102.SP102.SubP105]

6. Allocate functional and performance requirements to functions and subfunctions. [PA157.IG102.SP102.SubP106]

SP 3.3 Analyze Requirements

Analyze requirements to ensure that they are necessary and sufficient. *[PA157.IG102.SP103]*

In light of the operational concept and scenarios, the requirements for one level of the product hierarchy are analyzed to determine whether they are necessary and sufficient to meet the objectives of higher levels of the product hierarchy. The analyzed requirements then provide the basis for more detailed and precise requirements for lower levels of the product hierarchy. [PA157.IG102.SP103.N102]

As requirements are defined, their relationship to higher level requirements and the higher level defined functionality must be understood. One of the other actions is the determination of which key requirements will be used to track technical progress. For instance, the weight of a product or size of a software product may be monitored through development based on its risk. [PA157.IG102.SP103.N101]

Typical Work Products

1. Requirements defects reports [PA157.IG102.SP103.W101]
2. Proposed requirements changes to resolve defects [PA157.IG102.SP103.W102]
3. Key requirements [PA157.IG102.SP103.W103]
4. Technical performance measures [PA157.IG102.SP103.W104]

Subpractices

1. Analyze stakeholder needs, expectations, constraints, and external interfaces to remove conflicts and to organize into related subjects. [PA157.IG102.SP103.SubP101]
2. Analyze requirements to determine whether they satisfy the objectives of higher level requirements. [PA157.IG102.SP103.SubP102]
3. Analyze requirements to ensure that they are complete, feasible, realizable, and verifiable. [PA157.IG102.SP103.SubP103]

While design determines the feasibility of a particular solution, this subpractice addresses knowing which requirements affect feasibility. [PA157.IG102.SP103.SubP103.N101]

4. Identify key requirements that have a strong influence on cost, schedule, functionality, risk, or performance. [PA157.IG102.SP103.SubP104]

5. Identify technical performance measures that will be tracked during the development effort. [PA157.IG102.SP103.SubP105]

   Refer to the Measurement and Analysis process area for more information about the use of measurements. [PA157.IG102.SP103.SubP105.R101]

6. Analyze operational concepts and scenarios to refine the customer needs, constraints, and interfaces and to discover new requirements. [PA157.IG102.SP103.SubP106]

   This analysis may result in more detailed operational concepts and scenarios as well as supporting the derivation of new requirements. [PA157.IG102.SP103.SubP106.N101]

SP 3.4 Analyze Requirements to Achieve Balance

Analyze requirements to balance stakeholder needs and constraints. [PA157.IG102.SP104]

Stakeholder needs and constraints can address cost, schedule, performance, functionality, reusable components, maintainability, or risk. [PA157.IG102.SP104.N102]

Typical Work Products

1. Assessment of risks related to requirements [PA157.IG102.SP104.W101]

Subpractices

1. Use proven models, simulations, and prototyping to analyze the balance of stakeholder needs and constraints. [PA157.IG102.SP104.SubP103]

   Results of the analyses can be used to reduce the cost of the product and the risk in developing the product. [PA157.IG102.SP104.SubP103.N101]

2. Perform a risk assessment on the requirements and functional architecture. [PA157.IG102.SP104.SubP101]

   Refer to the Risk Management process area for information about performing a risk assessment on customer and product requirements and the functional architecture. [PA157.IG102.SP104.SubP101.R101]

3. Examine product life-cycle concepts for impacts of requirements on risks. [PA157.IG102.SP104.SubP102]

SP 3.5 Validate Requirements with Comprehensive Methods

Validate requirements to ensure the resulting product will perform as intended in the user's environment using multiple techniques as appropriate. *[PA157.IG102.SP106]*

Requirements validation is performed early in the development effort to gain confidence that the requirements are capable of guiding a development that results in successful final validation. This activity should be integrated with risk management activities. Mature organizations will typically perform requirements validation in a more sophisticated way and will broaden the basis of the validation to include other stakeholder needs and expectations. These organizations will typically perform analyses, simulations, or prototypes to ensure that requirements will satisfy stakeholder needs and expectations.
[PA157.IG102.SP106.N102]

Typical Work Products

1. Record of analysis methods and results [PA157.IG102.SP106.W101]

Subpractices

1. Analyze the requirements to determine the risk that the resulting product will not perform appropriately in its intended-use environment. [PA157.IG102.SP106.SubP101]

2. Explore the adequacy and completeness of requirements by developing product representations (e.g., prototypes, simulations, models, scenarios, and storyboards) and by obtaining feedback about them from relevant stakeholders. [PA157.IG102.SP106.SubP102]

3. Assess the design as it matures in the context of the requirements validation environment to identify validation issues and expose unstated needs and customer requirements. [PA157.IG102.SP106.SubP103]

The following specific practice appears in the continuous representation as SP 3.5-1, but is subsumed in the staged representation by SP 3.5, Validate Requirements with Comprehensive Methods. The specific practice is presented here in gray only as informative material.

SP 3.5-1 Validate Requirements

Validate requirements to ensure the resulting product will perform appropriately in its intended-use environment. *[PA157.IG102.SP105]*

Typical Work Products

1. Results of requirements validation [PA157.IG102.SP105.W101]

Subpractices

1. Analyze the requirements to determine the risk that the resulting product will not perform appropriately in its intended-use environment. [PA157.IG102.SP105.SubP101]

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the requirements development process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for collecting stakeholder needs, formulating product and product-component requirements, and analyzing and validating those requirements. [PA157.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined requirements development process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the requirements development process. *[GP104]*

Elaboration:

Typically, this plan for performing the requirements development process is a part of the project plan as described in the Project Planning process area. [PA157.EL102]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the requirements development process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Special expertise in the application domain, methods for eliciting stakeholder needs, and methods and tools for specifying and analyzing customer, product, and product-component requirements may be required. [PA157.EL103]

Examples of other resources provided include the following tools: [PA157.EL104]

- Requirements specification tools
- Simulators and modeling tools
- Prototyping tools
- Scenario definition and management tools
- Requirements tracking tools

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the requirements development process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the requirements development process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA157.EL105]

- Application domain
- Requirements definition and analysis
- Requirements elicitation
- Requirements specification and modeling
- Requirements tracking

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the requirements development process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA157.EL106]

- Customer requirements
- Functional architecture
- Product and product-component requirements
- Interface requirements

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the requirements development process as planned. *[GP124]*

Elaboration:

Select relevant stakeholders from customers, end users, developers, producers, testers, suppliers, marketers, maintainers, disposal personnel, and others who may be affected by, or may affect, the product as well as the process. [PA157.EL113]

Examples of activities for stakeholder involvement include the following: [PA157.EL114]

- Reviewing the adequacy of requirements in meeting needs, expectations, constraints, and interfaces
- Establishing operational concepts and scenarios
- Assessing the adequacy of requirements
- Establishing product and product-component requirements
- Assessing product cost, schedule, and risk

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the requirements development process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA157.EL110]

- Cost, schedule, and effort expended for rework
- Defect density of requirements specifications

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the requirements development process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the requirements development process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA157.EL111]

- Collecting stakeholder needs
- Formulating product and product-component requirements
- Analyzing and validating product and product-component requirements

Examples of work products reviewed include the following: [PA157.EL112]

- Product requirements
- Product-component requirements
- Interface requirements
- Functional architecture

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the requirements development process with higher level management and resolve issues. *[GP112]*

TECHNICAL SOLUTION

Maturity Level 3

Purpose

The purpose of Technical Solution is to design, develop, and implement solutions to requirements. Solutions, designs, and implementations encompass products, product components, and product-related life-cycle processes either singly or in combinations as appropriate. [PA160]

Introductory Notes

The Technical Solution process area is applicable at any level of the product architecture and to every product, product component, product-related life-cycle process, and service. The process area focuses on the following: [PA160.N101]

- Evaluating and selecting solutions (sometimes referred to as "design approaches," "design concepts," or "preliminary designs") that potentially satisfy an appropriate set of allocated requirements
- Developing detailed designs for the selected solutions (detailed in the context of containing all the information needed to manufacture, code, or otherwise implement the design as a product or product component)
- Implementing the designs as a product or product component

Typically, these activities interactively support each other. Some level of design, at times fairly detailed, may be needed to select solutions. Product-component prototypes may be used as a means of gaining sufficient knowledge to develop a technical data package or a complete set of requirements. [PA160.N102]

Technical Solution specific practices apply not only to the product and product components but also to services and product-related life-cycle processes. The product-related life-cycle processes are developed in concert with the product or product component. Such development may include selecting and adapting existing processes (including standard processes) for use as well as developing new processes. [PA160.N103]

Processes associated with the Technical Solution process area receive the product and product-component requirements from the requirements management processes. The requirements management processes place the requirements, which originate in requirements development processes, under appropriate configuration management and maintain their traceability to previous requirements. [PA160.N104]

For a maintenance or sustainment organization, the requirements in need of maintenance actions or redesign may be driven by user needs or latent defects in the product components. New requirements may arise from changes in the operating environment. Such requirements can be uncovered during verification of the product(s) where actual performance can be compared against the specified performance and unacceptable degradation can be identified. Processes associated with the Technical Solution process area should be used to perform the maintenance or sustainment design efforts. [PA160.N105]

Related Process Areas

Refer to the Requirements Development process area for more information about requirements allocations, establishing an operational concept, and interface requirements definition. [PA160.R101]

Refer to the Verification process area for more information about conducting peer reviews and verifying that the product and product components meet requirements. [PA160.R102]

Refer to the Decision Analysis and Resolution process area for more information about formal evaluation. [PA160.R103]

Refer to the Requirements Management process area for more information about managing requirements. The specific practices in the Requirements Management process area are performed interactively with those in the Technical Solution process area. [PA160.R104]

Refer to the Organizational Innovation and Deployment process area for more information about improving the organization's technology. [PA160.R105]

Specific and Generic Goals

SG 1 Select Product-Component Solutions [PA160.IG101]

Product or product-component solutions are selected from alternative solutions.

SG 2 Develop the Design [PA160.IG102]

Product or product-component designs are developed.

SG 3 **Implement the Product Design** [PA160.IG103]

Product components, and associated support documentation, are implemented from their designs.

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Select Product-Component Solutions [PA160.IG101]
- SP 1.1 Develop Detailed Alternative Solutions and Selection Criteria
- SP 1.2 Evolve Operational Concepts and Scenarios
- SP 1.3 Select Product-Component Solutions

SG 2 Develop the Design [PA160.IG102]
- SP 2.1 Design the Product or Product Component
- SP 2.2 Establish a Technical Data Package
- SP 2.3 Design Interfaces Using Criteria
- SP 2.4 Perform Make, Buy, or Reuse Analyses

SG 3 Implement the Product Design [PA160.IG103]
- SP 3.1 Implement the Design
- SP 3.2 Develop Product Support Documentation

GG 3 Institutionalize a Defined Process [CL104.GL101]
- GP 2.1 (CO 1) Establish an Organizational Policy
- GP 3.1 (AB 1) Establish a Defined Process
- GP 2.2 (AB 2) Plan the Process
- GP 2.3 (AB 3) Provide Resources
- GP 2.4 (AB 4) Assign Responsibility
- GP 2.5 (AB 5) Train People
- GP 2.6 (DI 1) Manage Configurations
- GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders
- GP 2.8 (DI 3) Monitor and Control the Process
- GP 3.2 (DI 4) Collect Improvement Information
- GP 2.9 (VE 1) Objectively Evaluate Adherence
- GP 2.10 (VE 2) Review Status with Higher Level Management

Specific Practices by Goal

SG 1 **Select Product-Component Solutions**

Product or product-component solutions are selected from alternative solutions. *[PA160.IG101]*

Alternative solutions and their relative merits are considered in advance of selecting a solution. Key requirements, design issues, and constraints are established for use in alternative solution analysis. Architectural features that provide a foundation for product improvement and evolution are considered. Use of commercial off-the-shelf (COTS) product components are considered relative to cost, schedule, performance, and risk. COTS alternatives may be used with or without modification. Sometimes such items may require modifications to aspects such as interfaces or a customization of some of the features to better achieve product requirements. [PA160.IG101.N101]

One indicator of a good design process is that the design was chosen after comparing and evaluating it against alternative solutions. Decisions on architecture, custom development versus off the shelf, and product-component modularization are typical of the design choices that are addressed. [PA160.IG101.N102]

Sometimes the search for solutions examines alternative instances of the same requirements with no allocations needed to lower level product components. Such is the case at the bottom of the product architecture. There are also cases where one or more of the solutions are fixed (e.g., a specific solution is directed or available product components, such as COTS, are investigated for use). [PA160.IG101.N103]

In the general case, solutions are defined as a set. That is, when defining the next layer of product components, the solution for each of the product components in the set is established. The alternative solutions are not only different ways of addressing the same requirements, but they also reflect a different allocation of requirements among the product components comprising the solution set. The objective is to optimize the set as a whole and not the individual pieces. There will be significant interaction with processes associated with the Requirements Development process area to support the provisional allocations to product components until a solution set is selected and final allocations established. [PA160.IG101.N104]

Product-related life-cycle processes are among the product-component solutions that are selected from alternative solutions. Examples of these product-related life-cycle processes are the manufacturing and the support processes. [PA160.IG101.N105]

SP 1.1 Develop Detailed Alternative Solutions and Selection Criteria

Develop detailed alternative solutions and selection criteria.

[PA160.IG101.SP102]

Refer to the Decision Analysis and Resolution process area for more information about establishing criteria used in making decisions.

[PA160.IG101.SP102.R101]

For Integrated Product and Process Development

The activity of selecting alternative solutions and issues to be subject to decision analyses and trade studies is accomplished by the involvement of relevant stakeholders. These stakeholders represent both business and technical functions and the concurrent development of the product and the product-related life-cycle processes (e.g., manufacturing, support, training, verification, and disposal). In this way, important issues surface earlier in product development than with traditional serial development and can be addressed before they become costly mistakes. [PA160.IG101.SP102.AMP101]

Detailed alternative solutions are an essential concept of the Technical Solution process area. They provide more accurate and comprehensive information about the solution than nondetailed alternatives. For example, characterization of performance based on design content rather than on simple estimating enables effective assessment and understanding of environment and operating concept impacts. Alternative solutions need to be identified and analyzed to enable the selection of a balanced solution across the life of the product in terms of cost, schedule, and technical performance. These solutions are based on proposed product architectures that address critical product qualities. Specific practices associated with the Develop the Design specific goal provide more information on developing potential product architectures that can be incorporated into alternative solutions for the product. [PA160.IG101.SP102.N104]

Alternative solutions span the acceptable range of cost, schedule, and performance. The product-component requirements are received and used along with design issues, constraints, and criteria to develop the alternative solutions. Selection criteria would typically address costs (e.g., time, people, money), benefits (e.g., performance, capability, effectiveness), and risks (e.g., technical, cost, schedule). Considerations for detailed alternative solutions and selection criteria include the following: [PA160.IG101.SP102.N102]

- Cost (development, procurement, support, product life cycle)
- Technical performance
- Complexity of the product component and product-related life-cycle processes
- Robustness to product operating and use conditions, operating modes, environments, and variations in product-related life-cycle processes
- Product expansion and growth
- Technology limitations
- Sensitivity to construction methods and materials
- Risk

- Evolution of requirements and technology
- Disposal
- Capabilities and limitations of end users and operators

The considerations listed above are a basic set; organizations should develop screening criteria to narrow down the list of alternatives that are consistent with their business objectives. Product life-cycle cost, while being a desirable parameter to minimize, may be outside the control of development organizations. A customer may not be willing to pay for features that cost more in the short term but ultimately decrease cost over the life of the product. In such cases, customers should at least be advised of any potential for reducing life-cycle costs. The criteria used in selections of final solutions should provide a balanced approach to costs, benefits, and risks. [PA160.IG101.SP102.N103]

Typical Work Products

1. Alternative solution screening criteria [PA160.IG101.SP102.W103]
2. Evaluations of new technologies [PA160.IG101.SP102.W104]
3. Alternative solutions [PA160.IG101.SP102.W101]
4. Selection criteria for final selection [PA160.IG101.SP102.W102]

Subpractices

1. Identify screening criteria to select a set of alternative solutions for consideration. [PA160.IG101.SP102.SubP101]
2. Identify technologies currently in use and new product technologies for competitive advantage. [PA160.IG101.SP102.SubP102]

   Refer to the Organizational Innovation and Deployment process area for more information about improving the organization's technology. *[PA160.IG101.SP102.SubP102.R101]*

   The project should identify technologies applied to current products and processes and monitor the progress of currently used technologies throughout the life of the project. The project should identify, select, evaluate, and invest in new technologies to achieve competitive advantage. Alternative solutions could include newly developed technologies, but could also include applying mature technologies in different applications or to maintain current methods.
   [PA160.IG101.SP102.SubP102.N101]
3. Generate alternative solutions. [PA160.IG101.SP102.SubP103]
4. Obtain a complete requirements allocation for each alternative.
   [PA160.IG101.SP102.SubP104]
5. Develop the criteria for selecting the best alternative solution.
   [PA160.IG101.SP102.SubP105]

Criteria should be included that address design issues for the life of the product, such as provisions for more easily inserting new technologies or the ability to better exploit commercial products. Examples include criteria related to open design or open architecture concepts for the alternatives being evaluated. [PA160.IG101.SP102.SubP105.N101]

6. Develop timeline scenarios for product operation and user interaction for each alternative solution. [PA160.IG101.SP102.SubP106]

The following specific practice appears in the continuous representation as SP 1.1-1, but is subsumed in the staged representation by SP 1.1, Develop Detailed Alternative Solutions and Selection Criteria. The specific practice is presented here in gray only as informative material.

SP 1.1-1 Develop Alternative Solutions and Selection Criteria

Develop alternative solutions and selection criteria. *[PA160.IG101.SP101]*

Refer to the Allocate Product-Component Requirements specific practice in the Requirements Development process area for more information about obtaining provisional allocations of requirements to solution alternatives for the product components. *[PA160.IG101.SP101.R101]*

Refer to the Decision Analysis and Resolution process area for more information about establishing selection criteria and identifying alternatives. *[PA160.IG101.SP101.R102]*

Refer to the Requirements Management process area for more information about managing the provisional and established allocated requirements. *[PA160.IG101.SP101.R103]*

Alternatives are based on potential product architectures and span a design space of feasible solutions. The Design Product or Product Component specific practice of the Develop the Design specific goal contains more information about developing potential product architectures to incorporate into alternative solutions for the product. [PA160.IG101.SP101.N101]

As selections are made, the design space may be constricted and other alternatives examined until the most promising (i.e., optimal) solutions that meet requirements and criteria are identified. The selection criteria identify the key factors that provide a basis for the selection of the solution. These criteria should provide clear discrimination and an indication of success in arriving at a balanced solution across the life of the product. They typically include measures of cost, schedule, performance, and risk. [PA160.IG101.SP101.N102]

The alternative solutions evaluated frequently encompass alternative requirement allocations to different product components. These alternatives may also be structured to evaluate the use of COTS solutions in the product architecture. Processes associated with the Requirements Development process area would then be employed to provide a more complete and robust provisional allocation of requirements to the alternative solutions. [PA160.IG101.SP101.N103]

Selection of the best solution establishes the requirements provisionally allocated to that solution as the set of allocated requirements. The circumstances in which it would not be useful to examine alternative solutions are infrequent in new developments. However, developments of precedented product components are candidates for not examining, or only minimally examining, alternative solutions. [PA160.IG101.SP101.N104]

Typical Work Products

1. Alternative solutions [PA160.IG101.SP101.W101]
2. Selection criteria [PA160.IG101.SP101.W102]

Subpractices

1. Establish and maintain a process or processes for identifying solution alternatives, selection criteria, and design issues.

   [PA160.IG101.SP101.SubP101]

   Selection criteria are influenced by a wide variety of factors driven by the requirements imposed on the project as well as the product life cycle. For example, criteria related to mitigating cost and schedule risks may influence a greater preference for COTS solutions provided such selections do not result in unacceptable risks for the remaining product components to be developed. When using existing items, such as COTS, either with or without modification, criteria dealing with diminishing sources of supply or technological obsolescence should be examined, as well as criteria capturing the benefits of standardization, maintaining relationships with suppliers, and so forth. The criteria used in selections should provide a balanced approach to costs, benefits, and risks.

   [PA160.IG101.SP101.SubP101.N101]

2. Identify alternative groupings of requirements that characterize sets of solution alternatives that span the feasible design space.

   [PA160.IG101.SP101.SubP102]

   Effective employment of COTS alternatives can provide special challenges. Knowledgeable designers familiar with candidate COTS alternatives may explore architectural opportunities to exploit potential COTS payoffs.

   [PA160.IG101.SP101.SubP102.N101]

3. Identify design issues for each solution alternative in each set of alternatives. [PA160.IG101.SP101.SubP103]

4. Characterize design issues and take appropriate action.
[PA160.IG101.SP101.SubP104]

   Appropriate action could be to characterize the issues as a risk for risk management, adjust the solution alternative to preclude the issues, or reject the solution alternative and replace it with a different alternative.
[PA160.IG101.SP101.SubP104.N101]

5. Obtain a complete requirements allocation for each alternative.
[PA160.IG101.SP101.SubP105]

6. Document the rationale for each alternative set of solutions.
[PA160.IG101.SP101.SubP106]

SP 1.2 Evolve Operational Concepts and Scenarios

Evolve the operational concept, scenarios, and environments to describe the conditions, operating modes, and operating states specific to each product component. *[PA160.IG101.SP103]*

Refer to the Establish Operational Concepts and Scenarios specific practice of the Requirements Development process area for information on product-level influences and implications of product-component operations. *[PA160.IG101.SP103.R101]*

For Systems Engineering

Integrate the operational concepts and scenarios produced by various individuals or groups for each level of physical product decomposition. *[PA160.IG101.SP103.AMP101]*

Operational concepts and scenarios are evolved to facilitate the selection of product-component solutions that, when implemented, will satisfy the intended use of the product. Operational concepts and scenarios document the interaction of the product components with the environment, users, and other product components, regardless of engineering discipline. They should be documented for operations, product deployment, delivery, support (including maintenance and sustainment), training, and disposal and for all modes and states.
[PA160.IG101.SP103.N101]

The environments (operating, support, training, etc.) also need to be evolved. The environment of any given product component will be influenced by other product components as well as the external environment. [PA160.IG101.SP103.N102]

Typical Work Products

1. Product-component operational concepts, scenarios, and environments for all product-related life-cycle processes (e.g., operations, support, training, manufacturing, deployment, fielding, delivery, and disposal) [PA160.IG101.SP103.W101]

2. Timeline analyses of product-component interactions [PA160.IG101.SP103.W102]

3. Use cases [PA160.IG101.SP103.W104]

Subpractices

1. Evolve the operational concepts and scenarios to a degree of detail appropriate for the product component. [PA160.IG101.SP103.SubP101]

2. Evolve the operational environments for the product components. [PA160.IG101.SP103.SubP102]

   The environments may include thermal, stress, and electromagnetic and other elements that need to be documented. [PA160.IG101.SP103.SubP102.N101]

SP 1.3 Select Product-Component Solutions

Select the product-component solutions that best satisfy the criteria established. *[PA160.IG101.SP104]*

Refer to the Allocate Product-Component Requirements and Identify Interface Requirements specific practices of the Requirements Development process area for information on establishing the allocated requirements for product components and interface requirements among product components. *[PA160.IG101.SP104.R101]*

Refer to the Decision Analysis and Resolution process area for more information about formal evaluations. *[PA160.IG101.SP104.R102]*

Selecting product components that best satisfy the criteria establishes the requirement allocations to product components. Lower level requirements are generated from the selected alternative and used to develop the product-component design. Interface requirements among product components are described, primarily functionally. Physical interface descriptions are included in the documentation for interfaces to items and activities external to the product. [PA160.IG101.SP104.N101]

The description of the solutions and the rationale for selection are documented. The documentation evolves throughout development as solutions and detailed designs are developed and those designs are implemented. Maintaining a record of rationale is critical to downstream decision making. Such records keep downstream stakeholders from redoing work and provide insights to apply technology as it becomes available in applicable circumstances. [PA160.IG101.SP104.N102]

Typical Work Products

1. Product-component selection decisions and rationale [PA160.IG101.SP104.W101]
2. Documented relationships between requirements and product components [PA160.IG101.SP104.W102]
3. Documented solutions, evaluations, and rationale [PA160.IG101.SP104.W103]

Subpractices

1. Evaluate each alternative solution/set of solutions against the selection criteria established in the context of the operating concepts, operating modes, and operating states. [PA160.IG101.SP104.SubP101]
2. Based on the evaluation of alternatives, assess the adequacy of the selection criteria and update these criteria as necessary. [PA160.IG101.SP104.SubP102]
3. Identify and resolve issues with the alternative solutions and requirements. [PA160.IG101.SP104.SubP103]
4. Select the best set of alternative solutions that satisfy the established selection criteria. [PA160.IG101.SP104.SubP104]
5. Establish the requirements associated with the selected set of alternatives as the set of allocated requirements to those product components. [PA160.IG101.SP104.SubP105]
6. Identify the product-component solutions that will be reused or acquired. [PA160.IG101.SP104.SubP107]

   Refer to the Supplier Agreement Management process area for more information about acquiring products and product components. *[PA160.IG101.SP104.SubP107.R101]*
7. Establish and maintain the documentation of the solutions, evaluations, and rationale. [PA160.IG101.SP104.SubP106]

SG 2 Develop the Design

Product or product-component designs are developed. *[PA160.IG102]*

Product or product-component designs must provide the appropriate content not only for implementation, but also for other phases of the product life cycle such as modification, reprocurement, maintenance, sustainment, and installation. The design documentation provides a reference to support mutual understanding of the design by relevant stakeholders and supports future changes to the design both during development and in subsequent phases of the product life cycle. A complete design description is documented in a technical data package that includes a full range of features and parameters including form, fit, function, interface, manufacturing process characteristics, and other parameters. Established organizational or project design standards (e.g., checklists, templates, object frameworks) form the basis for achieving a high degree of definition and completeness in design documentation. [PA160.IG102.N101]

For Integrated Product and Process Development

The integrated teams develop the designs of the appropriate product-related life-cycle processes concurrently with the design of the product. These processes may be selected without modification from the organization's set of standard processes, if appropriate. [PA160.IG102.AMP101]

SP 2.1 Design the Product or Product Component

Develop a design for the product or product component.

[PA160.IG102.SP101]

Product design consists of two broad phases that may overlap in execution: preliminary and detailed design. Preliminary design establishes product capabilities and the product architecture, including product partitions, product-component identifications, system states and modes, major intercomponent interfaces, and external product interfaces. Detailed design fully defines the structure and capabilities of the product components. [PA160.IG102.SP101.N101]

Refer to the Requirements Development process area for more information about developing architecture requirements.

[PA160.IG102.SP101.N101.R101]

Architecture definition is driven from a set of architectural requirements developed during the requirements development processes. These requirements express the qualities and performance points that are critical to the success of the product. The architecture defines structural elements and coordination mechanisms that either directly satisfy requirements or support the achievement of the requirements as the details of the product design are established. Architectures may include standards and design rules governing development of product components and their interfaces as well as guidance to aid product developers. Specific practices in the Select Product-Component Solutions specific goal contain more information about using product architectures as a basis for alternative solutions. [PA160.IG102.SP101.N102]

Architects postulate and develop a model of the product, making judgments about allocation of requirements to product components including hardware and software. Multiple architectures, supporting alternative solutions, may be developed and analyzed to determine the advantages and disadvantages in the context of the architectural requirements. [PA160.IG102.SP101.N103]

Operational concepts and scenarios are used to generate use cases and quality scenarios that are used to refine the architecture. They are also used as a means to evaluate the suitability of the architecture for its intended purpose during architecture evaluations, which are conducted periodically throughout product design. The Evolve Operational Concepts and Scenarios specific practice gives more information about elaborating operational concepts and scenarios used in architecture evaluation. [PA160.IG102.SP101.N104]

Refer to the Establish Operational Concepts and Scenarios specific practice of the Requirements Development process area for information about developing operational concepts and scenarios used in architecture evaluation. *[PA160.IG102.SP101.N104.R101]*

For Software Engineering

In addition to tasks identified above, software architecture definition may include: [PA160.IG102.SP101.N104.AMP101]

- *Establishing the structural relations of partitions and rules regarding interfaces between elements within partitions, and between partitions*
- *Identifying major internal interfaces and all external interfaces of software*
- *Identifying software product components*
- *Defining software coordination mechanisms*
- *Establishing infrastructure capabilities and services*
- *Developing product-component templates or classes and frameworks*
- *Establishing design rules and authority for making decisions*
- *Defining a process/thread model*
- *Defining physical deployment of software to hardware*
- *Identifying major reuse approaches and sources*

During detailed design, the product architecture details are finalized, product components are completely defined, and interfaces are fully characterized. Product-component designs may be optimized for certain qualities or performance characteristics. Designers may evaluate the use of legacy or COTS products for the product components. As the design matures, the requirements assigned to lower level product components are tracked to ensure those requirements are satisfied. [PA160.IG102.SP101.N105]

Refer to the Requirements Management process area for more information about tracking requirements for product components. [PA160.IG102.SP101.N105.R101]

For Software Engineering

Detailed design is focused on software product-component development. The internal structure of product components is defined, data schema are generated, algorithms are developed, and heuristics are established to provide product-component capabilities that satisfy allocated requirements. [PA160.IG102.SP101.N105.AMP101]

Typical Work Products

1. Product architecture [PA160.IG102.SP101.W101]
2. Product-component designs [PA160.IG102.SP101.W102]

Subpractices

1. Establish and maintain criteria against which the design can be evaluated. [PA160.IG102.SP101.SubP101]

Examples of attributes, in addition to expected performance, for which design criteria can be established, include the following: [PA160.IG102.SP101.SubP101.N101]

- Modular
- Clear
- Simple
- Maintainable
- Verifiable
- Portable
- Reliable
- Accurate
- Secure
- Scalable
- Usable

2. Identify, develop, or acquire the design methods appropriate for the product. [PA160.IG102.SP101.SubP102]

Effective design methods can embody a wide range of activities, tools, and descriptive techniques. Whether a given method is effective or not depends on the situation. Two companies may have very effective design methods for products in which they specialize, but these methods may not be effective in cooperative ventures. Highly sophisticated methods are not necessarily effective in the hands of designers that have not been trained in the use of the methods.
[PA160.IG102.SP101.SubP102.N101]

Whether or not a method is effective also depends on how much assistance it provides the designer, and the cost effectiveness of that assistance. For example, a multiyear prototyping effort may not be appropriate for a simple product component but might be the right thing to do for an unprecedented, expensive, and complex product development. Rapid prototyping techniques, however, may be highly effective for many product components. Methods that use tools to ensure that a design will encompass all the necessary attributes needed to implement the product-component design can be very effective. For example, a design tool that "knows" the capabilities of the manufacturing processes can allow the variability of the manufacturing process to be accounted for in the design tolerances. [PA160.IG102.SP101.SubP102.N102]

Examples of techniques and methods that facilitate effective design include the following: [PA160.IG102.SP101.SubP102.N103]

- Prototypes
- Structural models
- Object-oriented design
- Essential systems analysis
- Entity relationship models
- Design reuse
- Design patterns

3. Ensure that the design adheres to applicable design standards and criteria. [PA160.IG102.SP101.SubP103]

Examples of design standards include the following (some or all of these standards may be design criteria, particularly in circumstances where the standards have not been established): [PA160.IG102.SP101.SubP103.N101]

- Operator interface standards
- Safety standards
- Production constraints
- Design tolerances
- Parts standards (e.g., production scrap and waste)

4. Ensure that the design adheres to allocated requirements. [PA160.IG102.SP101.SubP104]

   Identified COTS product components must be taken into account. For example, putting existing product components into the product architecture might modify the requirements and the requirements allocation. [PA160.IG102.SP101.SubP104.N101]

5. Document the design. [PA160.IG102.SP101.SubP105]

SP 2.2 Establish a Technical Data Package

Establish and maintain a technical data package. *[PA160.IG102.SP103]*

A technical data package provides the developer with a comprehensive description of the product or product component as it is developed. Such a package also provides procurement flexibility in a variety of circumstances such as performance-based contracting or build to print. [PA160.IG102.SP103.N102]

The design is recorded in a technical data package that is created during preliminary design to document the architecture definition. This technical data package is maintained throughout the life of the product to record essential details of the product design. The technical data package provides the description of a product or product component (including product-related life-cycle processes if not handled as separate product components) that supports an acquisition strategy, or the implementation, production, engineering, and logistics support phases of the product life cycle. The description includes the definition of the required design configuration and procedures to ensure adequacy of product or product-component performance. It includes all applicable technical data such as drawings, associated lists, specifications, design descriptions, design databases, standards, performance requirements, quality assurance provisions, and packaging details. The technical data package includes a description of the selected alternative solution that was chosen for implementation. [PA160.IG102.SP103.N106]

A technical data package should include the following if such information is appropriate for the type of product and product component (for example, material and manufacturing requirements may not be useful for product components associated with software services or processes): [PA160.IG102.SP103.N103]

- Product architecture description
- Allocated requirements
- Product-component descriptions
- Product-related life-cycle process descriptions, if not described as separate product components
- Key product characteristics
- Required physical characteristics and constraints
- Interface requirements
- Materials requirements (bills of material and material characteristics)
- Fabrication and manufacturing requirements (for both the original equipment manufacturer and field support)
- The verification criteria used to ensure that requirements have been achieved
- Conditions of use (environments) and operating/usage scenarios, modes and states for operations, support, training, manufacturing, disposal, and verifications throughout the life of the product
- Rationale for decisions and characteristics (requirements, requirement allocations, and design choices)

Because design descriptions can involve a very large amount of data and be crucial to successful product-component development, it is advisable to establish criteria for organizing the data and for selecting the data content. It is particularly useful to use the product architecture as a means of organizing this data and abstracting views that are clear and relevant to an issue or feature of interest. These views include the following: [PA160.IG102.SP103.N104]

- Customers
- Requirements
- The environment
- Functional
- Logical
- Security
- Data
- States/modes
- Construction
- Management

These views are documented in the technical data package.
[PA160.IG102.SP103.N105]

Typical Work Products

1. Technical data package [PA160.IG102.SP103.W101]

Subpractices

1. Determine the number of levels of design and the appropriate level of documentation for each design level. [PA160.IG102.SP103.SubP101]

   Determining the number of levels of product components (e.g., subsystem, hardware configuration item, circuit board, computer software configuration item [CSCI], computer software product component, computer software unit) that require documentation and requirements traceability is important to manage documentation costs and to support integration and verification plans.
   [PA160.IG102.SP103.SubP101.N101]

2. Base detailed design descriptions on the allocated product-component requirements, architecture, and higher level designs.
   [PA160.IG102.SP103.SubP102]

3. Document the design in the technical data package.
   [PA160.IG102.SP103.SubP103]

4. Document the rationale for key (i.e., significant effect on cost, schedule, or technical performance) decisions made or defined.
   [PA160.IG102.SP103.SubP104]

5. Revise the technical data package as necessary.
[PA160.IG102.SP103.SubP105]

SP 2.3 Design Interfaces Using Criteria

Design comprehensive product-component interfaces in terms of established and maintained criteria. *[PA160.IG102.SP105]*

Interface designs include the following: [PA160.IG102.SP105.N101]

- Origination
- Destination
- Stimulus and data characteristics for software
- Electrical, mechanical, and functional characteristics for hardware

The criteria for interfaces frequently reflect a comprehensive list of critical parameters that must be defined, or at least investigated, to ascertain their applicability. These parameters are often peculiar to a given type of product (e.g., software, mechanical, electrical) and are often associated with safety, security, durability, and mission-critical characteristics. [PA160.IG102.SP105.N102]

Typical Work Products

1. Interface design specifications [PA160.IG102.SP105.W101]
2. Interface control documents [PA160.IG102.SP105.W102]
3. Interface specification criteria [PA160.IG102.SP105.W103]
4. Rationale for selected interface design [PA160.IG102.SP105.W104]

Subpractices

1. Define interface criteria. [PA160.IG102.SP105.SubP101]

   These criteria can be a part of the organizational process assets.
   [PA160.IG102.SP105.SubP101.N101]

   Refer to the Organizational Process Definition process area for more information about establishing and maintaining organizational process assets. *[PA160.IG102.SP105.SubP101.N101.R101]*

2. Apply the criteria to the interface design alternatives.
   [PA160.IG102.SP105.SubP102]

   Refer to the Decision Analysis and Resolution process area for more information about identifying criteria and selecting alternatives based on those criteria. *[PA160.IG102.SP105.SubP102.R101]*

3. Document the selected interface designs and the rationale for the selection. [PA160.IG102.SP105.SubP103]

The following specific practice appears in the continuous representation as SP 2.3-1, but is subsumed in the staged representation by SP 2.3, Design Interfaces Using Criteria. The specific practice is presented here in gray only as informative material.

SP 2.3-1 Establish Interface Descriptions

Establish and maintain the solution for product-component interfaces. [PA160.IG102.SP104]

The product-component interface description covers interfaces between the following: [PA160.IG102.SP104.N101]

- Product components and product components
- Lower level product components and higher level product components
- Product components and product-related life-cycle processes
- Product components and external items

Typical Work Products

1. Interface design [PA160.IG102.SP104.W101]
2. Interface design documents [PA160.IG102.SP104.W102]

Subpractices

1. Identify and document interfaces associated with other product components. [PA160.IG102.SP104.SubP101]
2. Identify interfaces associated with external items. [PA160.IG102.SP104.SubP102]
3. Identify interfaces between product components and the product-related life-cycle processes. [PA160.IG102.SP104.SubP103]

   For example, such interfaces could include those between a product component to be fabricated and the jigs and fixtures used to enable that fabrication during the manufacturing process. [PA160.IG102.SP104.SubP103.N101]
4. Ensure that the solution includes the interface requirements developed in the requirements development processes. [PA160.IG102.SP104.SubP104]

Refer to the Identify Interface Requirements specific practice in the Requirements Development process area for more information about identifying product and product-component interface requirements. [PA160.IG102.SP104.SubP104.R101]

SP 2.4 Perform Make, Buy, or Reuse Analyses

Evaluate whether the product components should be developed, purchased, or reused based on established criteria. [PA160.IG102.SP106]

The determination of what products or product components will be acquired is frequently referred to as a "make-or-buy analysis." It is based on an analysis of the needs of the project. This make-or-buy analysis begins early in the project during the first iteration of design, continues during the design process, and is completed with the decision to develop, acquire, or reuse the product. [PA160.IG102.SP106.N103]

Refer to the Requirements Development process area for more information about determining the product and product-component requirements. [PA160.IG102.SP106.N103.R101]

Refer to the Requirements Management process area for more information about managing requirements. [PA160.IG102.SP106.N103.R102]

Factors affecting the make-or-buy decision include the following: [PA160.IG102.SP106.N104]

- Functions the products or services will provide and how these functions will fit into the project
- Available project resources and skills
- Costs of acquiring versus developing internally
- Critical delivery and integration dates
- Strategic business alliances, including high-level business requirements
- Market research of available products, including COTS products
- Functionality and quality of available products
- Skills and capabilities of potential suppliers
- Impact on core competencies
- Licenses, warrantees, responsibilities, and limitations associated with products being acquired
- Product availability
- Proprietary issues
- Risk reduction

Many of these factors are addressed by the project. [PA160.IG102.SP106.N105]

The make-or-buy decision can be conducted using a formal evaluation approach. [PA160.IG102.SP106.N106]

Refer to the Decision Analysis and Resolution process area for more information about defining criteria and alternatives and performing formal evaluations. *[PA160.IG102.SP106.N106.R101]*

As technology evolves, so does the rationale for choosing to develop or purchase a product component. While complex development efforts may favor purchasing an off-the-shelf product component, advances in productivity and tools may provide an opposing rationale. Off-the-shelf products may have incomplete or inaccurate documentation and may or may not be supported in the future. [PA160.IG102.SP106.N101]

Once the decision is made to purchase an off-the-shelf product component, the requirements are used to establish a supplier agreement. There are times when "off the shelf" refers to an existing item that may not be readily available in the marketplace. For example, some types of aircraft and engines are not truly "off the shelf" but can be readily procured. In some cases the use of such non-developed items is in situations where the specifics of the performance and other product characteristics expected need to be within the limits specified. In these cases, the requirements and acceptance criteria may need to be included in the supplier agreement and managed. In other cases, the off-the-shelf product is literally off the shelf (word processing software, for example) and there is no agreement with the supplier that needs to be managed. [PA160.IG102.SP106.N102]

Refer to the Supplier Agreement Management process area for more information about how to address the acquisition of the product components that will be purchased. *[PA160.IG102.SP106.N102.R101]*

Typical Work Products

1. Criteria for design and product-component reuse [PA160.IG102.SP106.W101]
2. Make-or-buy analyses [PA160.IG102.SP106.W102]
3. Guidelines for choosing COTS product components [PA160.IG102.SP106.W103]

Subpractices

1. Develop criteria for the reuse of product-component designs. [PA160.IG102.SP106.SubP102]
2. Analyze designs to determine if product components should be developed, reused, or purchased. [PA160.IG102.SP106.SubP103]

3. When purchased or non-developmental (COTS, government off the shelf, and reuse) items are selected, plan for their maintenance. [PA160.IG102.SP106.SubP101]

For Software Engineering

Consider how the compatibility of future releases of an operating system and a database manager will be handled. *[PA160.IG102.SP106.SubP101.AMP101]*

SG 3 Implement the Product Design

Product components, and associated support documentation, are implemented from their designs. *[PA160.IG103]*

Product components are implemented from the designs established by the specific practices in the Develop the Design specific goal. The implementation usually includes unit testing of the product components before sending them to product integration and development of end-user documentation. [PA160.IG103.N101]

SP 3.1 Implement the Design

Implement the designs of the product components. *[PA160.IG103.SP101]*

For Software Engineering

Software code is a typical software product component. *[PA160.IG103.SP101.AMP101]*

Once the design has been completed, it is implemented as a product component. The characteristics of that implementation depend on the type of product component. [PA160.IG103.SP101.N101]

Design implementation at the top level of the product hierarchy involves the specification of each of the product components at the next level of the product hierarchy. This activity includes the allocation, refinement, and verification of each product component. It also involves the coordination between the various product-component development efforts. [PA160.IG103.SP101.N103]

Refer to the Requirements Development process area for more information about the allocation and refinement of requirements. *[PA160.IG103.SP101.N103.R101]*

Refer to the Product Integration process area for more information about the management of interfaces and the integration of products and product components. *[PA160.IG103.SP101.N103.R102]*

Example characteristics of this implementation are as follows: [PA160.IG103.SP101.N102]

- Software is coded.
- Data is documented.
- Services are documented.
- Electrical and mechanical parts are fabricated.
- Product-unique manufacturing processes are put into operation.
- Processes are documented.
- Facilities are constructed.
- Materials are produced (e.g., a product-unique material could be a petroleum, oil, or lubricant, or a new alloy).

Typical Work Products

1. Implemented design [PA160.IG103.SP101.W101]

Subpractices

1. Use effective methods to implement the product components.
   [PA160.IG103.SP101.SubP101]

For Software Engineering

Examples of software coding methods include the following:
[PA160.IG103.SP101.SubP101.AMP101]

- *Structured programming*
- *Object-oriented programming*
- *Automatic code generation*
- *Software code reuse*
- *Use of applicable design patterns*

For Systems Engineering

Examples of appropriate fabrication methods include the following:
[PA160.IG103.SP101.SubP101.AMP102]

- *Casting*
- *Molding*
- *Forming*
- *Joining*
- *Machining*
- *Tooling*
- *Welding*
- *Extruding*

2. Adhere to applicable standards and criteria. [PA160.IG103.SP101.SubP102]

For Software Engineering

Examples of software coding standards include the following: [PA160.IG103.SP101.SubP102.AMP101]

- *Language standards*
- *Naming conventions for variables*
- *Acceptable language structures*
- *Structure and hierarchy of software product components*
- *Format of code and comments*

For Software Engineering

Examples of software coding criteria include the following: [PA160.IG103.SP101.SubP102.AMP102]

- *Modularity*
- *Clarity*
- *Simplicity*
- *Structured (e.g., no GOTOs, one entrance, and one exit)*
- *Maintainability*

For Systems Engineering

Examples of standards include the following: [PA160.IG103.SP101.SubP102.AMP103]

- *Standard Parts Lists*
- *Standard drawing requirements*
- *International Organization for Standardization (ISO) T3303 standards for manufactured parts*

For Systems Engineering

Examples of criteria include the following: [PA160.IG103.SP101.SubP102.AMP104]

- *Maintainability*
- *Reliability*
- *Safety*

3. Conduct peer reviews of the selected product components.
[PA160.IG103.SP101.SubP103]

Refer to the Verification process area for more information about conducting peer reviews. [PA160.IG103.SP101.SubP103.R101]

4. Perform unit testing of the product component as appropriate.
[PA160.IG103.SP101.SubP104]

Note that unit testing is not limited to software. Unit testing involves the testing of individual hardware or software units or groups of related items prior to integration of those items. [PA160.IG103.SP101.SubP104.N101]

Refer to the Verification process area for more information about verification methods and procedures and about verifying work products against their specified requirements.

[PA160.IG103.SP101.SubP104.N101.R101]

For Software Engineering

Examples of unit testing methods include the following:

[PA160.IG103.SP101.SubP104.N101.AMP101]

- *Statement coverage testing*
- *Branch coverage testing*
- *Predicate coverage testing*
- *Path coverage testing*
- *Boundary value testing*
- *Special value testing*

5. Revise the product component as necessary. [PA160.IG103.SP101.SubP105]

An example of when the product component may need to be revised is when problems surface during implementation that could not be foreseen during design.

[PA160.IG103.SP101.SubP105.N101]

SP 3.2 Develop Product Support Documentation

Develop and maintain the end-use documentation. *[PA160.IG103.SP102]*

This specific practice develops and maintains the documentation that will be used to install, operate, and maintain the product.

[PA160.IG103.SP102.N101]

Typical Work Products

1. End-user training materials [PA160.IG103.SP102.W101]
2. User's manual [PA160.IG103.SP102.W102]
3. Operator's manual [PA160.IG103.SP102.W103]
4. Maintenance manual [PA160.IG103.SP102.W104]
5. Online help [PA160.IG103.SP102.W105]

Subpractices

1. Review the requirements, design, product, and test results to ensure that issues affecting the installation, operation, and maintenance documentation are identified and resolved. [PA160.IG103.SP102.SubP101]

2. Use effective methods to develop the installation, operation, and maintenance documentation. [PA160.IG103.SP102.SubP102]

3. Adhere to the applicable documentation standards. [PA160.IG103.SP102.SubP103]

Examples of documentation standards include the following: [PA160.IG103.SP102.SubP103.N101]

- Compatibility with designated word processors
- Acceptable fonts
- Numbering of pages, sections, and paragraphs
- Consistency with a designated style manual
- Use of abbreviations
- Security classification markings
- Internationalization requirements

4. Develop preliminary versions of the installation, operation, and maintenance documentation in early phases of the project life cycle for review by the relevant stakeholders. [PA160.IG103.SP102.SubP104]

5. Conduct peer reviews of the installation, operation, and maintenance documentation. [PA160.IG103.SP102.SubP105]

   Refer to the Verification process area for more information about conducting peer reviews. *[PA160.IG103.SP102.SubP105.R101]*

6. Revise the installation, operation, and maintenance documentation as necessary. [PA160.IG103.SP102.SubP106]

Examples of when documentation may need to be revised include when the following events occur: [PA160.IG103.SP102.SubP106.N101]

- Requirements change
- Design changes are made
- Product changes are made
- Documentation errors are identified
- Workaround fixes are identified

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the technical solution process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for addressing the iterative cycle in which product-component solutions are selected, product and product-component designs are developed, and the product-component designs are implemented. [PA160.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined technical solution process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the technical solution process. *[GP104]*

Elaboration:

Typically, this plan for performing the technical solution process is a part of the project plan as described in the Project Planning process area. [PA160.EL102]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the technical solution process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Special facilities may be required for developing, designing, and implementing solutions to requirements. When necessary, the facilities required for the activities in the Technical Solution process area are developed or purchased. [PA160.EL111]

Examples of other resources provided include the following tools: [PA160.EL104]

- Design specification tools
- Simulators and modeling tools
- Prototyping tools
- Scenario definition and management tools
- Requirements tracking tools
- Interactive documentation tools

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the technical solution process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the technical solution process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA160.EL105]

- Application domain of the product and product components
- Design methods
- Interface design
- Unit testing techniques
- Standards (e.g., product, safety, human factors, environmental)

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the technical solution process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA160.EL106]

- Product, product component, process, service, and interface designs
- Technical data packages
- Interface design documents
- Criteria for design and product-component reuse
- Implemented designs (e.g., software code, fabricated product components)
- User, installation, operation, and maintenance documentation

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the technical solution process as planned. *[GP124]*

Elaboration:

Select relevant stakeholders from customers, end users, developers, producers, testers, suppliers, marketers, maintainers, disposal personnel, and others who may be affected by, or may affect, the product as well as the process. [PA160.EL113]

Examples of activities for stakeholder involvement include the following: [PA160.EL114]

- Developing alternative solutions and selection criteria
- Evolving operational concept and scenarios
- Obtaining approval on external interface specifications and design descriptions
- Developing the technical data package
- Assessing the make, buy, or reuse alternatives for product components
- Implementing the design

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the technical solution process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA160.EL108]

- Cost, schedule, and effort expended for rework
- Percentage of requirements addressed in the product or product-component design
- Size and complexity of the product, product components, interfaces, and documentation
- Defect density of technical solutions work products

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the technical solution process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the technical solution process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA160.EL110]

- Selecting product-component solutions
- Developing product and product-component designs
- Implementing product-component designs

Examples of work products reviewed include the following: [PA160.EL112]

- Technical data packages
- Product, product-component, and interface designs
- Implemented designs (e.g., software code, fabricated product components)
- User, installation, operation, and maintenance documentation

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the technical solution process with higher level management and resolve issues. *[GP112]*

PRODUCT INTEGRATION

Maturity Level 3

Purpose

The purpose of Product Integration is to assemble the product from the product components, ensure that the product, as integrated, functions properly, and deliver the product. [PA147]

Introductory Notes

This process area addresses the integration of product components into more complex product components or into complete products. The term "integration" is used in this sense throughout this process area and is not to be confused with integration of people or activities that may be described elsewhere in the model. [PA147.N101]

The scope of this process area is to achieve complete product integration through progressive assembly of product components, in one stage or in incremental stages, according to a defined integration sequence and procedures. [PA147.N102]

A critical aspect of product integration is the management of internal and external interfaces of the products and product components to ensure compatibility among the interfaces. Attention should be paid to interface management throughout the project. [PA147.N103]

Product integration is more than just a one-time assembly of the product components at the conclusion of design and fabrication. Product integration can be conducted incrementally, using an iterative process of assembling product components, evaluating them, and then assembling more product components. This process may begin with analysis and simulations (e.g., threads, rapid prototypes, virtual prototypes, and physical prototypes) and steadily progress through increasingly more realistic incremental functionality until the final product is achieved. In each successive build, prototypes (virtual, rapid, or physical) are constructed, evaluated, improved, and reconstructed based upon knowledge gained in the evaluation process. The degree of virtual vs. physical prototyping required depends on the functionality of the design tools, the complexity of the product, and its associated risk. There is a high probability that the product, integrated in this manner, will pass product verification and validation. For some products, the last integration phase will occur when the product is deployed at its intended operational site. [PA147.N104]

Related Process Areas

Refer to the Requirements Development process area for more information about identifying interface requirements. [PA147.R101]

Refer to the Technical Solution process area for more information about defining the interfaces and the integration environment (when the integration environment needs to be developed). [PA147.R102]

Refer to the Verification process area for more information about verifying the interfaces, the integration environment, and the progressively assembled product components. [PA147.R103]

Refer to the Validation process area for more information about performing validation of the product components and the integrated product. [PA147.R104]

Refer to the Risk Management process area for more information about identifying risks and the use of prototypes in risk mitigation for both interface compatibility and product-component integration. [PA147.R105]

Refer to the Decision Analysis and Resolution process area for more information about using a formal evaluation process for selecting the appropriate integration sequence and procedures and for deciding whether the integration environment should be acquired or developed. [PA147.R106]

Refer to the Configuration Management process area for more information about managing changes to interface definitions and about the distribution of information. [PA147.R107]

Refer to the Supplier Agreement Management process area for more information about acquiring product components or parts of the integration environment. [PA147.R108]

Specific and Generic Goals

SG 1 Prepare for Product Integration [PA147.IG101]

Preparation for product integration is conducted.

SG 2 Ensure Interface Compatibility [PA147.IG102]

The product-component interfaces, both internal and external, are compatible.

SG 3 Assemble Product Components and Deliver the Product [PA147.IG103]

Verified product components are assembled and the integrated, verified, and validated product is delivered.

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Prepare for Product Integration [PA147.IG101]

- SP 1.1 Determine Integration Sequence
- SP 1.2 Establish the Product Integration Environment
- SP 1.3 Establish Product Integration Procedures and Criteria

SG 2 Ensure Interface Compatibility [PA147.IG102]

- SP 2.1 Review Interface Descriptions for Completeness
- SP 2.2 Manage Interfaces

SG 3 Assemble Product Components and Deliver the Product [PA147.IG103]

- SP 3.1 Confirm Readiness of Product Components for Integration
- SP 3.2 Assemble Product Components
- SP 3.3 Evaluate Assembled Product Components
- SP 3.4 Package and Deliver the Product or Product Component

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 3.1	(AB 1)	Establish a Defined Process
GP 2.2	(AB 2)	Plan the Process
GP 2.3	(AB 3)	Provide Resources
GP 2.4	(AB 4)	Assign Responsibility
GP 2.5	(AB 5)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 3.2	(DI 4)	Collect Improvement Information
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

Specific Practices by Goal

SG 1 Prepare for Product Integration

Preparation for product integration is conducted. *[PA147.IG101]*

Preparing for integration of product components involves establishing and maintaining an integration sequence, the environment for performing the integration, and integration procedures. The specific practices of the Prepare for Product Integration specific goal build on each other in the following way. The first specific practice determines the sequence for product and product-component integration. The second determines the environment that will be used to carry out the product and product-component integration. The third develops procedures and criteria for product and product-component integration. Preparation for integration starts early in the project and the integration sequence is developed concurrently with the practices in the Technical Solution process area. [PA147.IG101.N101]

SP 1.1 Determine Integration Sequence

Determine the product-component integration sequence.

[PA147.IG101.SP101]

The product components that are integrated may include those that are a part of the product to be delivered along with test equipment, test software, or other integration items such as fixtures. Once you have analyzed alternative test and assembly integration sequences, select the best integration sequence. [PA147.IG101.SP101.N101]

The product integration sequence can provide for incremental assembly and evaluation of product components that provide a problem-free foundation for incorporation of other product components as they become available, or for prototypes of high-risk product components. [PA147.IG101.SP101.N103]

The integration sequence should be harmonized with the selection of solutions and the design of product and product components in the Technical Solution process area. [PA147.IG101.SP101.N104]

Refer to the Decision Analysis and Resolution process area for more information about using a formal evaluation process to selecting the appropriate product integration sequence. *[PA147.IG101.SP101.N104.R101]*

Refer to the Risk Management process area for more information about identifying and handling risks associated with the integration sequence. *[PA147.IG101.SP101.N104.R102]*

Refer to the Supplier Agreement Management process area for more information about transitioning acquired product components and the need for handling those product components in the product integration sequence. *[PA147.IG101.SP101.N104.R103]*

Typical Work Products

1. Product integration sequence [PA147.IG101.SP101.W101]

2. Rationale for selecting or rejecting integration sequences
[PA147.IG101.SP101.W102]

Subpractices

1. Identify the product components to be integrated.
[PA147.IG101.SP101.SubP101]

2. Identify the product integration verifications to be performed using the definition of the interfaces between the product components.
[PA147.IG101.SP101.SubP102]

3. Identify alternative product-component integration sequences.
[PA147.IG101.SP101.SubP103]

   This can include defining the specific tools and test equipment to support the product integration. [PA147.IG101.SP101.SubP103.N101]

4. Select the best integration sequence. [PA147.IG101.SP101.SubP105]

5. Periodically review the product integration sequence and revise as needed. [PA147.IG101.SP101.SubP106]

   Assess the product integration sequence to ensure that variations in production and delivery schedules have not had an adverse impact on the sequence or compromised the factors upon which earlier decisions were made.
[PA147.IG101.SP101.SubP106.N101]

6. Record the rationale for decisions made and deferred.
[PA147.IG101.SP101.SubP107]

SP 1.2 Establish the Product Integration Environment

Establish and maintain the environment needed to support the integration of the product components. *[PA147.IG101.SP102]*

Refer to the Technical Solution process area for more information about make-or-buy decisions. *[PA147.IG101.SP102.R101]*

The environment for product integration can either be acquired or developed. To establish an environment, requirements for the purchase or development of equipment, software, or other resources will need to be developed. These requirements are gathered when implementing the processes associated with the Requirements Development process area. The product integration environment may include the reuse of existing organizational resources. The decision to acquire or develop the product integration environment is addressed in the processes associated with the Technical Solution process area. [PA147.IG101.SP102.N101]

The environment required at each step of the product integration process may include test equipment, simulators (taking the place of nonavailable product components), pieces of real equipment, and recording devices. [PA147.IG101.SP102.N102]

Typical Work Products

1. Verified environment for product integration [PA147.IG101.SP102.W101]
2. Support documentation for the product integration environment [PA147.IG101.SP102.W102]

Subpractices

1. Identify the requirements for the product integration environment. [PA147.IG101.SP102.SubP101]
2. Identify verification criteria and procedures for the product integration environment. [PA147.IG101.SP102.SubP102]
3. Decide whether to make or buy the needed product integration environment. [PA147.IG101.SP102.SubP103]

   Refer to the Supplier Agreement Management process area for more information about acquiring parts of the integration environment. *[PA147.IG101.SP102.SubP103.R101]*
4. Develop an integration environment if a suitable environment cannot be acquired. [PA147.IG101.SP102.SubP104]

   For unprecedented, complex projects, the product integration environment can be a major development. As such, it would involve project planning, requirements development, technical solutions, verification, validation, and risk management. [PA147.IG101.SP102.SubP104.N101]
5. Maintain the product integration environment throughout the project. [PA147.IG101.SP102.SubP105]
6. Dispose of those portions of the environment that are no longer useful. [PA147.IG101.SP102.SubP106]

SP 1.3 Establish Product Integration Procedures and Criteria

Establish and maintain procedures and criteria for integration of the product components. *[PA147.IG101.SP103]*

Procedures for the integration of the product components can include such things as the number of incremental iterations to be performed and details of the expected tests and other evaluations to be carried out at each stage. [PA147.IG101.SP103.N102]

Criteria can indicate the readiness of a product component for integration or its acceptability. [PA147.IG101.SP103.N103]

Procedures and criteria for product integration address the following: [PA147.IG101.SP103.N105]

- Level of testing for build components
- Verification of interfaces
- Thresholds of performance deviation
- Derived requirements for the assembly and its external interfaces
- Allowable substitutions of components
- Testing environment parameters
- Limits on cost of testing
- Quality/cost tradeoffs for integration operations
- Probability of proper functioning
- Delivery rate and its variation
- Lead time from order to delivery
- Personnel availability
- Availability of the integration facility/line/environment

Criteria can be defined for how the product components are to be verified and the functions they are expected to have. Criteria can be defined for how the assembled product components and final integrated product are to be validated and delivered. [PA147.IG101.SP103.N106]

Criteria may also constrain the degree of simulation permitted for a product component to pass a test, or may constrain the environment to be used for the integration test. [PA147.IG101.SP103.N104]

Typical Work Products

1. Product integration procedures [PA147.IG101.SP103.W101]
2. Product integration criteria [PA147.IG101.SP103.W102]

Subpractices

1. Establish and maintain product integration procedures for the product components. [PA147.IG101.SP103.SubP101]
2. Establish and maintain criteria for product-component integration and evaluation. [PA147.IG101.SP103.SubP102]
3. Establish and maintain criteria for validation and delivery of the integrated product. [PA147.IG101.SP103.SubP103]

SG 2 Ensure Interface Compatibility

The product-component interfaces, both internal and external, are compatible. *[PA147.IG102]*

Many product integration problems arise from unknown or uncontrolled aspects of both internal and external interfaces. Effective management of product-component interface requirements, specifications, and designs helps ensure that implemented interfaces will be complete and compatible. [PA147.IG102.N101]

SP 2.1 Review Interface Descriptions for Completeness

Review interface descriptions for coverage and completeness. *[PA147.IG102.SP101]*

The interfaces should include, in addition to product-component interfaces, all the interfaces with the product integration environment. [PA147.IG102.SP101.N101]

Typical Work Products

1. Categories of interfaces [PA147.IG102.SP101.W101]
2. List of interfaces per category [PA147.IG102.SP101.W102]
3. Mapping of the interfaces to the product components and product integration environment [PA147.IG102.SP101.W103]

Subpractices

1. Review interface data for completeness and ensure complete coverage of all interfaces. [PA147.IG102.SP101.SubP101]

   Consider all the product components and prepare a relationship table. Interfaces are usually classified in three main classes: environmental, physical, and functional. Typical categories for these classes include the following: mechanical, fluid, sound, electrical, climatic, electromagnetic, thermal, message, and the human-machine or human interface. [PA147.IG102.SP101.SubP101.N101]

   For Software Engineering

   In the message category for software, interfaces include the following: *[PA147.IG102.SP101.SubP101.N101.AMP101]*

   - *Origination*
   - *Destination*
   - *Stimulus*
   - *Protocols and data characteristics*

For Systems Engineering

For mechanical and electronic components, the interface data should include the following: [PA147.IG102.SP101.SubP101.N101.AMP102]

- *Mechanical interfaces (e.g., weight and size, center of gravity, clearance of parts in operation, space required for maintenance, fixed links, mobile links, shocks and vibrations received from the bearing structure)*
- *Noise interfaces (e.g., noise transmitted by the structure, noise transmitted in the air, acoustics)*
- *Climatic interfaces (e.g., temperature, humidity, pressure, salinity)*
- *Thermal interfaces (e.g., heat dissipation, transmission of heat to the bearing structure, air conditioning characteristics)*
- *Fluid interfaces (e.g., fresh water inlet/outlet, seawater inlet/outlet for a naval/coastal product, air conditioning, compressed air, nitrogen, fuel, lubricating oil, exhaust gas outlet)*
- *Electrical interfaces (e.g., power supply consumption by network with transients and peak values; non-sensitive control signal for power supply, communications, etc.; sensitive signal [analog links]; disturbing signal [microwave, etc.]; grounding signal to comply with the TEMPEST standard)*
- *Electromagnetic interfaces (e.g., magnetic field, radio and radar links, optical band link wave guides, coaxial and optical fibers)*
- *Human-machine interface (e.g., audio or voice synthesis, audio or voice recognition, display [analog dial, TV screen, or liquid crystal display, indicators' light emitting diodes], manual controls [pedal, joystick, ball, keys, push buttons, touch screen])*

2. Ensure that product components and interfaces are marked to ensure easy and correct connection to the joining product component. [PA147.IG102.SP101.SubP102]

3. Periodically review the adequacy of interface descriptions. [PA147.IG102.SP101.SubP103]

   Once established, the interface descriptions must be periodically reviewed to ensure there is no deviation between the existing descriptions and the products being developed, processed, produced, or bought. [PA147.IG102.SP101.SubP103.N101]

SP 2.2 Manage Interfaces

Manage internal and external interface definitions, designs, and changes for products and product components. [PA147.IG102.SP102]

Interface requirements drive the development of the interfaces necessary to integrate product components. Managing product and product-component interfaces starts very early in the development of the product. The definitions and designs for interfaces affect not only the product components and external systems, but can also affect the verification and validation environments. [PA147.IG102.SP102.N104]

Refer to the Requirements Development process area for more information about requirements for interfaces. *[PA147.IG102.SP102.N104.R101]*

Refer to the Technical Solution process area for more information about design of interfaces between product components. *[PA147.IG102.SP102.N104.R102]*

Refer to the Requirements Management process area for more information about managing the changes to the interface requirements. *[PA147.IG102.SP102.N104.R103]*

Refer to the Configuration Management process area for more information about distributing changes to the interface descriptions (specifications), so that everyone can know the current state of the interfaces. *[PA147.IG102.SP102.N104.R104]*

Management of the interfaces includes maintenance of the consistency of the interfaces throughout the life of the product, and resolution of conflict, noncompliance, and change issues. [PA147.IG102.SP102.N101]

The interfaces should include, in addition to product-component interfaces, all the interfaces with the environment as well as other environments for verification, validation, operations, and support. [PA147.IG102.SP102.N102]

The interface changes are documented, maintained, and readily accessible. [PA147.IG102.SP102.N103]

Typical Work Products

1. Table of relationships among the product components and the external environment (e.g., main power supply, fastening product, computer bus system) [PA147.IG102.SP102.W101]
2. Table of relationships between the different product components [PA147.IG102.SP102.W102]
3. List of agreed-to interfaces defined for each pair of product components, when applicable [PA147.IG102.SP102.W103]
4. Reports from the interface control working group meetings [PA147.IG102.SP102.W104]
5. Action items for updating interfaces [PA147.IG102.SP102.W105]
6. Application program interface (API) [PA147.IG102.SP102.W106]

7. Updated interface description or agreement [PA147.IG102.SP102.W107]

Subpractices

1. Ensure the compatibility of the interfaces throughout the life of the product. [PA147.IG102.SP102.SubP101]

2. Resolve conflict, noncompliance, and change issues. [PA147.IG102.SP102.SubP102]

3. Maintain a repository for interface data accessible to project participants. [PA147.IG102.SP102.SubP103]

   A common accessible repository for interface data provides a mechanism to ensure that everyone knows where the current interface data resides and can access it for use. [PA147.IG102.SP102.SubP103.N101]

SG 3 Assemble Product Components and Deliver the Product

Verified product components are assembled and the integrated, verified, and validated product is delivered. *[PA147.IG103]*

Integration of product components proceeds according to the product integration sequence and available procedures. Before integration, each product component should be confirmed to be compliant with its interface requirements. Product components are assembled into larger, more complex product components. These assembled product components are checked for correct interoperation. This process continues until product integration is complete. If, during this process, problems are identified, the problem should be documented and a corrective action process initiated. [PA147.IG103.N101]

Ensure that the assembly of the product components into larger and more complex product components is conducted according to the product integration sequence and available procedures. The timely receipt of needed product components and the involvement of the right people contribute to the successful integration of the product components that compose the product. [PA147.IG103.N102]

SP 3.1 Confirm Readiness of Product Components for Integration

Confirm, prior to assembly, that each product component required to assemble the product has been properly identified, functions according to its description, and that the product-component interfaces comply with the interface descriptions. *[PA147.IG103.SP101]*

Refer to the Verification process area for more information about verifying product components. *[PA147.IG103.SP101.R101]*

Refer to the Technical Solution process area for more information about unit test of product components. [PA147.IG103.SP101.R102]

The purpose of this specific practice is to ensure that the properly identified product component that meets its description can actually be assembled according to the product integration sequence and available procedures. The product components are checked for quantity, obvious damage, and consistency between the product component and interface descriptions. [PA147.IG103.SP101.N101]

Those conducting product integration are ultimately responsible for checking to make sure everything is proper with the product components before assembly. [PA147.IG103.SP101.N102]

Typical Work Products

1. Acceptance documents for the received product components [PA147.IG103.SP101.W101]
2. Delivery receipts [PA147.IG103.SP101.W102]
3. Checked packing lists [PA147.IG103.SP101.W103]
4. Exception reports [PA147.IG103.SP101.W104]
5. Waivers [PA147.IG103.SP101.W105]

Subpractices

1. Track the status of all product components as soon as they become available for integration. [PA147.IG103.SP101.SubP101]
2. Ensure that product components are delivered to the product integration environment in accordance with the product integration sequence and available procedures. [PA147.IG103.SP101.SubP102]
3. Confirm the receipt of each properly identified product component. [PA147.IG103.SP101.SubP103]
4. Ensure that each received product component meets its description. [PA147.IG103.SP101.SubP104]
5. Check the configuration status against the expected configuration. [PA147.IG103.SP101.SubP105]
6. Perform pre-check (for example, by a visual inspection and using basic measures) of all the physical interfaces before connecting product components together. [PA147.IG103.SP101.SubP106]

SP 3.2 Assemble Product Components

Assemble product components according to the product integration sequence and available procedures. [PA147.IG103.SP102]

Refer to the Verification process area for more information about verifying assembled product components. [PA147.IG103.SP102.R101]

Refer to the Validation process area for more information about validating assembled product components. [PA147.IG103.SP102.R102]

(For users of the continuous representation, this is a capability level 1 specific practice. Product integration processes at capability level 1 or 2 may not include procedures and criteria, which are created in the Establish Product Integration Procedures and Criteria specific practice at capability level 3. When there are no procedures or criteria established, use the sequence established by the Determine Integration Sequence specific practice to accomplish capability level 1 performance.) [PA147.IG103.SP102.N102]

The assembly activities of this specific practice and the evaluation activities of the next specific practice are conducted iteratively, from the initial product components, through the interim assemblies of product components, to the product as a whole. [PA147.IG103.SP102.N101]

Typical Work Products

1. Assembled product or product components [PA147.IG103.SP102.W101]

Subpractices

1. Ensure the readiness of the product integration environment.
   [PA147.IG103.SP102.SubP101]

2. Ensure that the assembly sequence is properly performed.
   [PA147.IG103.SP102.SubP102]

   Record all appropriate information (e.g., configuration status, serial numbers of the product components, types, and calibration date of the meters).
   [PA147.IG103.SP102.SubP102.N101]

3. Revise the product integration sequence and available procedures as appropriate. [PA147.IG103.SP102.SubP104]

SP 3.3 Evaluate Assembled Product Components

Evaluate assembled product components for interface compatibility. *[PA147.IG103.SP103]*

This evaluation involves examining and testing assembled product components for performance, suitability, or readiness using the available procedures and environment. It is performed as appropriate for different stages of assembly of product components as identified in the product integration sequence and available procedures. The product integration sequence and available procedures may define a more refined integration and evaluation sequence than might be envisioned just by examining the product architecture. For example, if an assembly of product components is composed of four less complex product components, the integration sequence will not necessarily call for the simultaneous integration and evaluation of the four units as one. Rather, the four less complex units may be integrated progressively, one at a time, with an evaluation after each assembly operation prior to realizing the more complex product component that matched the specification in the product architecture. Alternatively, the integration sequence and available procedures could have determined that only a final evaluation was the best one to perform. [PA147.IG103.SP103.N101]

Typical Work Products

1. Exception reports [PA147.IG103.SP103.W102]
2. Interface evaluation reports [PA147.IG103.SP103.W103]
3. Product integration summary reports [PA147.IG103.SP103.W104]

Subpractices

1. Conduct the evaluation of assembled product components following the product integration sequence and available procedures. [PA147.IG103.SP103.SubP101]
2. Record the evaluation results. [PA147.IG103.SP103.SubP102]

Example results include the following: [PA147.IG103.SP103.SubP102.N101]

- Any adaptation required to the integration procedure
- Any change to the product configuration (spare parts, new release)
- Evaluation procedure deviations

SP 3.4 Package and Deliver the Product or Product Component

Package the assembled product or product component and deliver it to the appropriate customer. *[PA147.IG103.SP104]*

Refer to the Verification process area for more information about verifying the product or an assembly of product components before packaging. *[PA147.IG103.SP104.R101]*

Refer to the Validation process area for more information about validating the product or an assembly of product components before packaging. [PA147.IG103.SP104.R102]

The packaging requirements for some products may be addressed in their specifications and verification criteria. This is especially important when items are stored and transported by the customer. In such cases, there may be a spectrum of environmental and stress conditions specified for the package. In other circumstances, factors such as the following may become important: [PA147.IG103.SP104.N101]

- Economy and ease of transportation (e.g., containerization)
- Accountability (e.g., shrinkwrapping)
- Ease and safety of unpacking (e.g., sharp edges, strength of binding methods, childproofing, environmental friendliness of packing material, weight)

The adjustment required to fit product components together in the factory could be different from the one required to fit product components when installed on the operational site. In that case, the product's logbook for the customer should be used to record such specific parameters. [PA147.IG103.SP104.N102]

Typical Work Products

1. Packaged product or product components [PA147.IG103.SP104.W101]
2. Delivery documentation [PA147.IG103.SP104.W102]

Subpractices

1. Review the requirements, design, product, verification results, and documentation to ensure that issues affecting the packaging and delivery of the product are identified and resolved.
   [PA147.IG103.SP104.SubP101]
2. Use effective methods to package and deliver the assembled product. [PA147.IG103.SP104.SubP102]

For Software Engineering

Examples of software packaging and delivery methods include the following: [PA147.IG103.SP104.SubP102.AMP101]

- *Magnetic tape*
- *Diskettes*
- *Hardcopy documents*
- *Compact disks*
- *Other electronic distribution such as the Internet*

3. Satisfy the applicable requirements and standards for packaging and delivering the product. [PA147.IG103.SP104.SubP103]

For Software Engineering

Examples of requirements and standards for packaging and delivering the software include the following: [PA147.IG103.SP104.SubP103.AMP101]

- *Type of storage and delivery media*
- *Custodians of the master and backup copies of the software*
- *Required documentation*
- *Copyrights*
- *License provisions*
- *Security of the software*

For Systems Engineering

Examples of requirements and standards include those for safety, the environment, security, and transportability. [PA147.IG103.SP104.SubP103.AMP102]

4. Prepare the operational site for installation of the product. [PA147.IG103.SP104.SubP104]

   Preparing the operational site may be the responsibility of the customer or end users. [PA147.IG103.SP104.SubP104.N101]

5. Deliver the product and related documentation and confirm receipt. [PA147.IG103.SP104.SubP105]

6. Install the product at the operational site and confirm correct operation. [PA147.IG103.SP104.SubP106]

   Installing the product may be the responsibility of the customer or end users. In some circumstances, very little may need to be done to confirm correct operation. In other circumstances, final verification of the integrated product occurs at the operational site. [PA147.IG103.SP104.SubP106.N101]

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the product integration process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for developing product integration sequences, procedures, and an environment, ensuring interface compatibility among product components, assembling the product components, and delivering the product and product components. [PA147.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined product integration process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the product integration process. *[GP104]*

Elaboration:

This plan for performing the product integration process addresses the comprehensive planning for all of the specific practices in this process area, from the preparation for product integration all the way through to the delivery of the final product. [PA147.EL102]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the product integration process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Product-component interface coordination may be accomplished with an Interface Control Working Group consisting of people who represent external and internal interfaces. Such groups can be used to elicit needs for interface requirements development. [PA147.EL115]

Special facilities may be required for assembling and delivering the product. When necessary, the facilities required for the activities in the Product Integration process area are developed or purchased. [PA147.EL116]

Examples of other resources provided include the following tools: [PA147.EL117]

- Prototyping tools
- Analysis tools
- Simulation tools
- Interface management tools
- Assembly tools (e.g., compilers, make files, joining tools, jigs and fixtures)

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the product integration process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the product integration process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA147.EL105]

- Application domain
- Product integration procedures and criteria
- Organization's facilities for integration and assembly
- Assembly methods
- Packaging standards

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

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

[GP109]

Elaboration:

Examples of work products placed under configuration management include the following: [PA147.EL106]

- Acceptance documents for the received product components
- Evaluated assembled product and product components
- Product integration sequence
- Product integration procedures and criteria
- Updated interface description or agreement

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the product integration process as planned. *[GP124]*

Elaboration:

Select relevant stakeholders from customers, end users, developers, producers, testers, suppliers, marketers, maintainers, disposal personnel, and others who may be affected by, or may affect, the product as well as the process. [PA147.EL120]

Examples of activities for stakeholder involvement include the following: [PA147.EL121]

- Reviewing interface descriptions for completeness
- Establishing the product integration sequence
- Establishing the product integration procedures and criteria
- Assembling and delivering the product and product components
- Communicating the results after evaluation
- Communicating new, effective product integration processes to give affected people the opportunity to improve their performance

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the product integration process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA147.EL112]

- Product-component integration profile (e.g., product-component assemblies planned and performed, and number of exceptions found)
- Integration evaluation problem report trends (e.g., number written and number closed)
- Integration evaluation problem report aging (i.e., how long each problem report has been open)

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the product integration process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the product integration process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA147.EL114]

- Establishing and maintaining a product integration sequence
- Ensuring interface compatibility
- Assembling product components and delivering the product

Examples of work products reviewed include the following: [PA147.EL119]

- Product integration sequence
- Product integration procedures and criteria
- Acceptance documents for the received product components
- Assembled product and product components

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the product integration process with higher level management and resolve issues. *[GP112]*

VERIFICATION

Maturity Level 3

Purpose

The purpose of Verification is to ensure that selected work products meet their specified requirements. [PA150]

Introductory Notes

The Verification process area involves the following: verification preparation, verification performance, and identification of corrective action. [PA150.N101]

Verification includes verification of the product and intermediate work products against all selected requirements, including customer, product, and product-component requirements. [PA150.N102]

Verification is inherently an incremental process because it occurs throughout the development of the product and work products, beginning with verification of the requirements, progressing through the verification of the evolving work products, and culminating in the verification of the completed product. [PA150.N103]

The specific practices of this process area build upon each other in the following way: the Select Work Products for Verification specific practice enables the identification of the work products to be verified, the methods to be used to perform the verification, and the requirements to be satisfied by each selected work product. The Establish the Verification Environment specific practice enables the determination of the environment that will be used to carry out the verification. The Establish Verification Procedures and Criteria specific practice then enables the development of verification procedures and criteria that are aligned with the selected work products, requirements, methods, and characteristics of the verification environment. The Perform Verification specific practice conducts the verification according to the available methods, procedures, and criteria. [PA150.N110]

Verification of work products substantially increases the likelihood that the product will meet the customer, product, and product-component requirements. [PA150.N104]

The Verification and Validation process areas are similar, but they address different issues. Validation demonstrates that the product, as provided (or as it will be provided), will fulfill its intended use, whereas verification addresses whether the work product properly reflects the specified requirements. In other words, verification ensures that "you built it right;" whereas, validation ensures that "you built the right thing." [PA150.N105]

Peer reviews are an important part of verification and are a proven mechanism for effective defect removal. An important corollary is to develop a better understanding of the work products and the processes that produced them so defects can be prevented and process-improvement opportunities can be identified. [PA150.N106]

Peer reviews involve a methodical examination of work products by the producers' peers to identify defects and other changes that are needed. [PA150.N107]

Examples of peer review methods include the following: [PA150.N109]

- Inspections
- Structured walkthroughs

Related Process Areas

Refer to the Validation process area for more information about confirming that a product or product component fulfills its intended use when placed in its intended environment. [PA150.R102]

Refer to the Requirements Development process area for more information about the generation and development of customer, product, and product-component requirements. [PA150.R103]

Refer to the Requirements Management process area for more information about managing requirements. [PA150.R104]

Specific and Generic Goals

SG 1 Prepare for Verification [PA150.IG101]

Preparation for verification is conducted.

SG 2 Perform Peer Reviews [PA150.IG102]

Peer reviews are performed on selected work products.

SG 3 Verify Selected Work Products [PA150.IG103]

Selected work products are verified against their specified requirements.

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Prepare for Verification [PA150.IG101]
- SP 1.1 Select Work Products for Verification
- SP 1.2 Establish the Verification Environment
- SP 1.3 Establish Verification Procedures and Criteria

SG 2 Perform Peer Reviews [PA150.IG102]
- SP 2.1 Prepare for Peer Reviews
- SP 2.2 Conduct Peer Reviews
- SP 2.3 Analyze Peer Review Data

SG 3 Verify Selected Work Products [PA150.IG103]
- SP 3.1 Perform Verification
- SP 3.2 Analyze Verification Results and Identify Corrective Action

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 3.1	(AB 1)	Establish a Defined Process
GP 2.2	(AB 2)	Plan the Process
GP 2.3	(AB 3)	Provide Resources
GP 2.4	(AB 4)	Assign Responsibility
GP 2.5	(AB 5)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 3.2	(DI 4)	Collect Improvement Information
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

Specific Practices by Goal

SG 1 Prepare for Verification

Preparation for verification is conducted. *[PA150.IG101]*

Up-front preparation is necessary to ensure that verification provisions are embedded in product and product-component requirements, designs, developmental plans, and schedules. Verification includes selection, inspection, testing, analyses, and demonstration of work products. [PA150.IG101.N101]

Methods of verification include, but are not limited to, inspections, peer reviews, audits, walkthroughs, analyses, simulations, testing, and demonstrations. [PA150.IG101.N102]

Preparation also entails the definition of support tools, test equipment and software, simulations, prototypes, and facilities. [PA150.IG101.N103]

SP 1.1 Select Work Products for Verification

Select the work products to be verified and the verification methods that will be used for each. *[PA150.IG101.SP101]*

Work products are selected based on their contribution to meeting project objectives and requirements, and to addressing project risks. [PA150.IG101.SP101.N104]

The work products to be verified may include those associated with maintenance, training, and support services. The work product requirements for verification are included with the verification methods. The verification methods address the technical approach to work product verification and the specific approaches that will be used to verify that specific work products meet their requirements. [PA150.IG101.SP101.N102]

For Software Engineering

Examples of verification methods include the following: *[PA150.IG101.SP101.N102.AMP101]*

- *Path coverage testing*
- *Load, stress, and performance testing*
- *Decision-table-based testing*
- *Functional-decomposition-based testing*
- *Test-case reuse*
- *Acceptance tests*

Selection of the verification methods typically begins with involvement in the definition of product and product-component requirements to ensure that these requirements are verifiable. Re-verification should be addressed by the verification methods to ensure that rework performed on work products did not cause unintended defects. [PA150.IG101.SP101.N103]

For Integrated Product and Process Development

The verification methods should be developed concurrently and iteratively with the product and product-component designs. *[PA150.IG101.SP101.N103.AMP101]*

Typical Work Products

1. Lists of work products selected for verification [PA150.IG101.SP101.W101]
2. Verification methods for each selected work product [PA150.IG101.SP101.W102]

Subpractices

1. Identify work products for verification. [PA150.IG101.SP101.SubP102]
2. Identify the requirements to be satisfied by each selected work product. [PA150.IG101.SP101.SubP103]

   Refer to the Maintain Bidirectional Traceability of Requirements specific practice in the Requirements Management process area to help identify the requirements for each work product. *[PA150.IG101.SP101.SubP103.R101]*
3. Identify the verification methods that are available for use. [PA150.IG101.SP101.SubP104]
4. Define the verification methods to be used for each selected work product. [PA150.IG101.SP101.SubP105]
5. Submit for integration with the project plan the identification of work products to be verified, the requirements to be satisfied, and the methods to be used. [PA150.IG101.SP101.SubP106]

   Refer to the Project Planning process area for information on coordinating with project planning. *[PA150.IG101.SP101.SubP106.R101]*

SP 1.2 Establish the Verification Environment

Establish and maintain the environment needed to support verification. *[PA150.IG101.SP102]*

An environment must be established to enable verification to take place. The verification environment may be acquired, developed, reused, modified, or a combination of these, depending on the needs of the project. [PA150.IG101.SP102.N101]

The type of environment required will depend on the work products selected for verification and the verification methods used. A peer review may require little more than a package of materials, reviewers, and a room. A product test may require simulators, emulators, scenario generators, data reduction tools, environmental controls, and interfaces with other systems. [PA150.IG101.SP102.N102]

Typical Work Products

1. Verification environment [PA150.IG101.SP102.W102]

Subpractices

1. Identify verification environment requirements. [PA150.IG101.SP102.SubP101]
2. Identify verification resources that are available for reuse and modification. [PA150.IG101.SP102.SubP102]
3. Identify verification equipment and tools. [PA150.IG101.SP102.SubP103]
4. Acquire verification support equipment and an environment, such as test equipment and software. [PA150.IG101.SP102.SubP104]

SP 1.3 Establish Verification Procedures and Criteria

Establish and maintain verification procedures and criteria for the selected work products. *[PA150.IG101.SP103]*

For Integrated Product and Process Development

The verification procedures and criteria should be developed concurrently and iteratively with the product and product-component designs. *[PA150.IG101.SP103.AMP101]*

Verification criteria are defined to ensure that the work products meet their requirements. [PA150.IG101.SP103.N101]

Examples of sources for verification criteria include the following: [PA150.IG101.SP103.N102]

- Product and product-component requirements
- Standards
- Organizational policies
- Test type
- Test parameters
- Parameters for tradeoff between quality and cost of testing
- Type of work products

Typical Work Products

1. Verification procedures [PA150.IG101.SP103.W101]
2. Verification criteria [PA150.IG101.SP103.W102]

Subpractices

1. Generate the set of comprehensive, integrated verification procedures for work products and any commercial off-the-shelf products, as necessary. [PA150.IG101.SP103.SubP101]
2. Develop and refine the verification criteria when necessary. [PA150.IG101.SP103.SubP102]

3. Identify the expected results, any tolerances allowed in observation, and other criteria for satisfying the requirements. [PA150.IG101.SP103.SubP104]

4. Identify any equipment and environmental components needed to support verification. [PA150.IG101.SP103.SubP105]

SG 2 Perform Peer Reviews

Peer reviews are performed on selected work products. *[PA150.IG102]*

Peer reviews involve a methodical examination of work products by the producers' peers to identify defects for removal and to recommend other changes that are needed. [PA150.IG102.N101]

The peer review is an important and effective engineering method implemented via inspections, structured walkthroughs, or a number of other collegial review methods. [PA150.IG102.N102]

Peer reviews are primarily applied to work products developed by the projects, but they can also be applied to other work products such as documentation and training work products that are typically developed by support groups. [PA150.IG102.N103]

SP 2.1 Prepare for Peer Reviews

Prepare for peer reviews of selected work products. *[PA150.IG102.SP101]*

Preparation activities for peer reviews typically include identifying the staff who will be invited to participate in the peer review of each work product, identifying the key reviewers who must participate in the peer review, preparing and updating any materials that will be used during the peer reviews (such as checklists and review criteria), and scheduling peer reviews. [PA150.IG102.SP101.N101]

Typical Work Products

1. Peer review schedule [PA150.IG102.SP101.W101]
2. Peer review checklist [PA150.IG102.SP101.W102]
3. Entry and exit criteria for work products [PA150.IG102.SP101.W103]
4. Criteria for requiring another peer review [PA150.IG102.SP101.W104]
5. Peer review training material [PA150.IG102.SP101.W105]
6. Selected work products to be reviewed [PA150.IG102.SP101.W106]

Subpractices

1. Determine what type of peer review will be conducted.
[PA150.IG102.SP101.SubP101]

> Examples of types of peer reviews include the following: [PA150.IG102.SP101.SubP101.N101]
>
> - Inspections
> - Structured walkthroughs
> - Active reviews

2. Define requirements for collecting data during the peer review.
[PA150.IG102.SP101.SubP102]

Refer to the Measurement and Analysis process area for information on identifying and collecting data.
[PA150.IG102.SP101.SubP102.R101]

3. Establish and maintain entry and exit criteria for the peer review.
[PA150.IG102.SP101.SubP103]

4. Establish and maintain criteria for requiring another peer review.
[PA150.IG102.SP101.SubP104]

5. Establish and maintain checklists to ensure that the work products are reviewed consistently. [PA150.IG102.SP101.SubP105]

> Examples of items addressed by the checklists include the following:
> [PA150.IG102.SP101.SubP105.N102]
>
> - Rules of construction
> - Design guidelines
> - Completeness
> - Correctness
> - Maintainability
> - Common defect types

The checklists are modified as necessary to address the specific type of work product and peer review. The peers of the checklist developers and potential users review the checklists. [PA150.IG102.SP101.SubP105.N101]

6. Develop a detailed peer review schedule, including the dates for peer review training and for when materials for peer reviews will be available. [PA150.IG102.SP101.SubP106]

7. Ensure that the work product satisfies the peer review entry criteria prior to distribution. [PA150.IG102.SP101.SubP107]

8. Distribute the work product to be reviewed and its related information to the participants early enough to enable participants to adequately prepare for the peer review. [PA150.IG102.SP101.SubP108]

9. Assign roles for the peer review as appropriate. [PA150.IG102.SP101.SubP109]

Examples of roles include the following: [PA150.IG102.SP101.SubP109.N101]

- Leader
- Reader
- Recorder
- Author

10. Prepare for the peer review by reviewing the work product prior to conducting the peer review. [PA150.IG102.SP101.SubP110]

SP 2.2 Conduct Peer Reviews

Conduct peer reviews on selected work products and identify issues resulting from the peer review. *[PA150.IG102.SP102]*

One of the purposes of conducting a peer review is to find and remove defects early. Peer reviews are performed incrementally, as work products are being developed. These reviews are structured and are not management reviews. [PA150.IG102.SP102.N101]

Peer reviews may be performed on key work products of specification, design, test, and implementation activities and specific planning work products. [PA150.IG102.SP102.N102]

The focus of the peer review should be on the work product in review, not on the person who produced it. [PA150.IG102.SP102.N103]

When issues arise during the peer review, they should be communicated to the primary developer of the work product for correction. [PA150.IG102.SP102.N104]

Refer to the Project Monitoring and Control process area for information about tracking issues that arise during a peer review.

[PA150.IG102.SP102.N104.R101]

Peer reviews should address the following guidelines: there must be sufficient preparation, the conduct must be managed and controlled, consistent and sufficient data must be recorded (an example is conducting a formal inspection), and action items must be recorded.

[PA150.IG102.SP102.N105]

Typical Work Products

1. Peer review results [PA150.IG102.SP102.W101]
2. Peer review issues [PA150.IG102.SP102.W102]
3. Peer review data [PA150.IG102.SP102.W103]

Subpractices

1. Perform the assigned roles in the peer review. [PA150.IG102.SP102.SubP101]
2. Identify and document defects and other issues in the work product. [PA150.IG102.SP102.SubP102]
3. Record the results of the peer review, including the action items. [PA150.IG102.SP102.SubP103]
4. Collect peer review data. [PA150.IG102.SP102.SubP104]

   Refer to the Measurement and Analysis process area for more information on data collection. *[PA150.IG102.SP102.SubP104.R101]*
5. Identify action items and communicate the issues to relevant stakeholders. [PA150.IG102.SP102.SubP105]
6. Conduct an additional peer review if the defined criteria indicate the need. [PA150.IG102.SP102.SubP106]
7. Ensure that the exit criteria for the peer review are satisfied. [PA150.IG102.SP102.SubP107]

SP 2.3 Analyze Peer Review Data

Analyze data about preparation, conduct, and results of the peer reviews. *[PA150.IG102.SP103]*

Refer to the Measurement and Analysis process area for more information about obtaining and analyzing data. *[PA150.IG102.SP103.R101]*

Typical Work Products

1. Peer review data [PA150.IG102.SP103.W101]
2. Peer review action items [PA150.IG102.SP103.W102]

Subpractices

1. Record data related to the preparation, conduct, and results of the peer reviews. [PA150.IG102.SP103.SubP101]

Typical data are product name, product size, composition of the peer review team, type of peer review, preparation time per reviewer, length of the review meeting, number of defects found, type and origin of defect, etc. Additional information on the work product being peer reviewed may be collected, such as size, development stage, operating modes examined, and requirements being evaluated. [PA150.IG102.SP103.SubP101.N101]

2. Store the data for future reference and analysis. [PA150.IG102.SP103.SubP102]

3. Protect the data to ensure that peer review data are not used inappropriately. [PA150.IG102.SP103.SubP103]

> Examples of inappropriate use of peer review data include using data to evaluate the performance of people and using data for attribution. [PA150.IG102.SP103.SubP103.N101]

4. Analyze the peer review data. [PA150.IG102.SP103.SubP104]

SG 3 Verify Selected Work Products

Selected work products are verified against their specified requirements. *[PA150.IG103]*

SP 3.1 Perform Verification

Perform verification on the selected work products. *[PA150.IG103.SP101]*

Verifying products and work products incrementally promotes early detection of problems and can result in the early removal of defects. These results of verification save considerable cost of fault isolation and rework associated with troubleshooting problems. [PA150.IG103.SP101.N101]

(For users of the continuous representation, this is a capability level 1 specific practice. Verification processes at capability level 1 or 2 may not include procedures and criteria, which are created in the Establish Verification Procedures and Criteria specific practice at capability level 3. When there are no procedures or criteria established, use the methods established by the Select Work Products for Verification specific practice to accomplish capability level 1 performance.)
[PA150.IG103.SP101.N102]

Typical Work Products

1. Verification results [PA150.IG103.SP101.W101]
2. Verification reports [PA150.IG103.SP101.W102]
3. Demonstrations [PA150.IG103.SP101.W103]
4. As-run procedures log [PA150.IG103.SP101.W104]

Subpractices

1. Perform verification of selected work products against their requirements. [PA150.IG103.SP101.SubP102]
2. Record the results of verification activities. [PA150.IG103.SP101.SubP103]
3. Identify action items resulting from verification of work products. [PA150.IG103.SP101.SubP104]
4. Document the "as-run" verification method and the deviations from the available methods and procedures discovered during its performance. [PA150.IG103.SP101.SubP105]

SP 3.2 Analyze Verification Results and Identify Corrective Action

Analyze the results of all verification activities and identify corrective action. *[PA150.IG103.SP102]*

Actual results must be compared to established verification criteria to determine acceptability. [PA150.IG103.SP102.N101]

The results of the analysis are recorded as evidence that verification was conducted. [PA150.IG103.SP102.N102]

For each work product, all available verification results are incrementally analyzed and corrective actions are initiated to ensure that the requirements have been met. Since a peer review is one of several verification methods, peer review data should be included in this analysis activity to ensure that the verification results are analyzed sufficiently. Analysis reports or "as-run" method documentation may also indicate that bad verification results are due to method problems, criteria problems, or a verification environment problem. [PA150.IG103.SP102.N103]

Refer to the corrective action practices of Project Monitoring and Control process area for more information on implementing corrective action. *[PA150.IG103.SP102.N103.R101]*

Typical Work Products

1. Analysis report (such as statistics on performances, causal analysis of nonconformances, comparison of the behavior between the real product and models, and trends) [PA150.IG103.SP102.W101]
2. Trouble reports [PA150.IG103.SP102.W102]
3. Change requests for the verification methods, criteria, and environment [PA150.IG103.SP102.W103]
4. Corrective actions to verification methods, criteria, and/or environment [PA150.IG103.SP102.W104]

Subpractices

1. Compare actual results to expected results. [PA150.IG103.SP102.SubP101]
2. Based on the established verification criteria, identify products that have not met their requirements or identify problems with the methods, procedures, criteria, and verification environment. [PA150.IG103.SP102.SubP102]
3. Analyze the verification data on defects. [PA150.IG103.SP102.SubP103]
4. Record all results of the analysis in a report. [PA150.IG103.SP102.SubP104]
5. Use verification results to compare actual measurements and performance to technical performance parameters. [PA150.IG103.SP102.SubP105]
6. Provide information on how defects may be resolved (including verification methods, criteria, and verification environment) and formalize it in a plan. [PA150.IG103.SP102.SubP106]

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the verification process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for establishing and maintaining verification methods, procedures, criteria, verification environment, performing peer reviews, and verifying selected work products. [PA150.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined verification process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the verification process. *[GP104]*

Elaboration:

Typically, this plan for performing the verification process is included in (or referenced by) the project plan, which is described in the Project Planning process area. [PA150.EL102]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the verification process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Special facilities may be required for verifying selected work products. When necessary, the facilities required for the activities in the Verification process area are developed or purchased. [PA150.EL110]

Certain verification methods may require special tools, equipment, facilities, and training (e.g., peer reviews may require meeting rooms and trained moderators; certain verification tests may require special test equipment and people skilled in the use of the equipment). [PA150.EL104]

Examples of other resources provided include the following tools: [PA150.EL103]

- Test management tools
- Test-case generators
- Test-coverage analyzers
- Simulators

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the verification process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the verification process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA150.EL105]

- Application domain
- Verification principles, standards, and methods (e.g., analysis, demonstration, inspection, test)
- Verification tools and facilities
- Peer review preparation and procedures
- Meeting facilitation

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the verification process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA150.EL106]

- Verification procedures and criteria
- Peer review training material
- Peer review data
- Verification reports

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the verification process as planned. *[GP124]*

Elaboration:

Select relevant stakeholders from customers, end users, developers, producers, testers, suppliers, marketers, maintainers, disposal personnel, and others who may be affected by, or may affect, the product as well as the process. [PA150.EL113]

Examples of activities for stakeholder involvement include the following: [PA150.EL114]

- Selecting work products and methods for verification
- Establishing verification procedures and criteria
- Conducting peer reviews
- Assessing verification results and identifying corrective action

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the verification process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA150.EL107]

- Verification profile (e.g., the number of verifications planned and performed, and the defects found; perhaps categorized by verification method or type)
- Number of defects detected by defect category
- Verification problem report trends (e.g., number written and number closed)
- Verification problem report status (i.e., how long each problem report has been open)

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the verification process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the verification process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA150.EL109]

- Selecting work products for verification
- Establishing and maintaining verification procedures and criteria
- Performing peer reviews
- Verifying selected work products

Examples of work products reviewed include the following: [PA150.EL112]

- Verification procedures and criteria
- Peer review checklists
- Verification reports

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the verification process with higher level management and resolve issues. *[GP112]*

VALIDATION

Maturity Level 3

Purpose

The purpose of Validation is to demonstrate that a product or product component fulfills its intended use when placed in its intended environment. [PA149]

Introductory Notes

Validation activities can be applied to all aspects of the product in any of its intended environments, such as operation, training, manufacturing, maintenance, and support services. The methods employed to accomplish validation can be applied to work products as well as to the product and product components. The work products (e.g., requirements, designs, prototypes) should be selected on the basis of which are the best predictors of how well the product and product component will satisfy user needs. [PA149.N105]

The validation environment should represent the intended environment for the product and product components as well as represent the intended environment suitable for validation activities with work products. [PA149.N106]

Validation demonstrates that the product, as provided, will fulfill its intended use; whereas, verification addresses whether the work product properly reflects the specified requirements. In other words, verification ensures that "you built it right;" whereas, validation ensures that "you built the right thing." Validation activities use approaches similar to verification (e.g., test, analysis, inspection, demonstration, or simulation). Often, the end users are involved in the validation activities. Both validation and verification activities often run concurrently and may use portions of the same environment. [PA149.N102]

Refer to the Verification process area for more information about verification activities. [PA149.N102.R101]

Where possible, validation should be accomplished using the product or product component operating in its intended environment. The entire environment may be used or only part of it. However, validation issues can be discovered early in the life of the project using work products. [PA149.N103]

When validation issues are identified, they are referred to the processes associated with the Requirements Development, Technical Solution, or Project Monitoring and Control process areas for resolution. [PA149.N104]

The specific practices of this process area build on each other in the following way. The Select Products for Validation specific practice enables the identification of the product or product component to be validated and the methods to be used to perform the validation. The Establish the Validation Environment specific practice enables the determination of the environment that will be used to carry out the validation. The Establish Validation Procedures and Criteria specific practice enables the development of validation procedures and criteria that are aligned with the characteristics of selected products, customer constraints on validation, methods, and the validation environment. The Perform Validation specific practice enables the performance of validation according to the methods, procedures, and criteria. [PA149.N107]

Related Process Areas

Refer to the Requirements Development process area for more information about requirements validation. [PA149.R101]

Refer to the Technical Solution process area for more information about transforming requirements into product specifications and for corrective action when validation issues are identified that affect the product or product-component design. [PA149.R102]

Refer to the Verification process area for more information about verifying that the product or product component meets its requirements. [PA149.R103]

Specific and Generic Goals

SG 1 **Prepare for Validation** [PA149.IG101]

Preparation for validation is conducted.

SG 2 **Validate Product or Product Components** [PA149.IG102]

The product or product components are validated to ensure that they are suitable for use in their intended operating environment.

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Prepare for Validation [PA149.IG101]

SP 1.1	Select Products for Validation
SP 1.2	Establish the Validation Environment
SP 1.3	Establish Validation Procedures and Criteria

SG 2 Validate Product or Product Components [PA149.IG102]

SP 2.1	Perform Validation
SP 2.2	Analyze Validation Results

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 3.1	(AB 1)	Establish a Defined Process
GP 2.2	(AB 2)	Plan the Process
GP 2.3	(AB 3)	Provide Resources
GP 2.4	(AB 4)	Assign Responsibility
GP 2.5	(AB 5)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 3.2	(DI 4)	Collect Improvement Information
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

Specific Practices by Goal

SG 1 Prepare for Validation

Preparation for validation is conducted. *[PA149.IG101]*

Preparation activities include selecting products and product components for validation and establishing and maintaining the validation environment, procedures, and criteria. The items selected for validation may include only the product or it may include appropriate levels of the product components that are used to build the product. Any product or product component may be subject to validation, including replacement, maintenance, and training products, to name a few.

[PA149.IG101.N101]

The environment required to validate the product or product component is prepared. The environment may be purchased or may be specified, designed, and built. The environments used for product integration and verification may be considered in collaboration with the validation environment to reduce cost and improve efficiency or productivity.

[PA149.IG101.N102]

SP 1.1 Select Products for Validation

Select products and product components to be validated and the validation methods that will be used for each. *[PA149.IG101.SP101]*

Products and product components are selected for validation on the basis of their relationship to user needs. For each product component, the scope of the validation (e.g., operational behavior, maintenance, training, and user interface) should be determined. [PA149.IG101.SP101.N104]

The requirements and constraints for performing validation are collected. Then, validation methods are selected based on their ability to demonstrate that user needs are satisfied. The validation methods not only define the technical approach to product validation, but also drive the needs for the facilities, equipment, and environments. This may result in the generation of lower level product-component requirements that are handled by the requirements development processes. Derived requirements, such as interface requirements to test sets and test equipment, may be generated. These requirements are also passed to the requirements development processes to ensure that the product or product components can be validated in an environment that supports the methods. [PA149.IG101.SP101.N101]

Validation methods should be selected early in the life of the project so they are clearly understood and agreed to by the relevant stakeholders. [PA149.IG101.SP101.N102]

The validation methods address the development, maintenance, support, and training for the product or product component as appropriate. [PA149.IG101.SP101.N103]

Typical Work Products

1. Lists of products and product components selected for validation [PA149.IG101.SP101.W101]
2. Validation methods for each product or product component [PA149.IG101.SP101.W102]
3. Requirements for performing validation for each product or product component [PA149.IG101.SP101.W103]
4. Validation constraints for each product or product component [PA149.IG101.SP101.W104]

Subpractices

1. Identify the key principles, features, and phases for product or product-component validation throughout the life of the project. [PA149.IG101.SP101.SubP101]

2. Determine which categories of user needs (operational, maintenance, training, or support) are to be validated. [PA149.IG101.SP101.SubP102]

   The product or product component must be maintainable and supportable in its intended operational environment. This specific practice also addresses the actual maintenance, training, and support services that may be delivered along with the product. [PA149.IG101.SP101.SubP102.N101]

   > An example of evaluation of maintenance concepts in the operational environment is a demonstration that maintenance tools are operating with the actual product. [PA149.IG101.SP101.SubP102.N102]

3. Select the product and product components to be validated. [PA149.IG101.SP101.SubP105]

4. Select the evaluation methods for product or product-component validation. [PA149.IG101.SP101.SubP103]

5. Review the validation selection, constraints, and methods with relevant stakeholders. [PA149.IG101.SP101.SubP104]

SP 1.2 Establish the Validation Environment

Establish and maintain the environment needed to support validation. *[PA149.IG101.SP102]*

The requirements for the validation environment are driven by the product or product components selected, by the type of the work products (e.g., design, prototype, final version), and by the methods of validation. These may yield requirements for the purchase or development of equipment, software, or other resources. These requirements are provided to the requirements development processes for development. The validation environment may include the reuse of existing resources. In this case, arrangements for the use of these resources must be made. Examples of the type of elements in a validation environment include the following: [PA149.IG101.SP102.N101]

- Test tools interfaced with the product being validated (e.g., scope, electronic devices, probes)
- Temporary embedded test software
- Recording tools for dump or further analysis and replay
- Simulated subsystems or components (by software, electronics, or mechanics)
- Simulated interfaced systems (e.g., a dummy warship for testing a naval radar)

- Real interfaced systems (e.g., aircraft for testing a radar with trajectory tracking facilities)
- Facilities and customer-supplied products
- The skilled people to operate or use all the above elements
- Dedicated computing or network test environment (e.g., pseudo-operational telecommunications-network testbed or facility with actual trunks, switches, and systems established for realistic integration and validation trials)

Early selection of the products or product components to be validated, the work products to be used in the validation, and the validation methods is needed to ensure that the validation environment will be available when necessary. [PA149.IG101.SP102.N102]

The validation environment should be carefully controlled to provide for replication, analysis of results, and re-validation of problem areas. [PA149.IG101.SP102.N103]

Typical Work Products

1. Validation environment [PA149.IG101.SP102.W101]

Subpractices

1. Identify validation environment requirements. [PA149.IG101.SP102.SubP101]
2. Identify customer-supplied products. [PA149.IG101.SP102.SubP102]
3. Identify reuse items. [PA149.IG101.SP102.SubP103]
4. Identify test equipment and tools. [PA149.IG101.SP102.SubP104]
5. Identify validation resources that are available for reuse and modification. [PA149.IG101.SP102.SubP105]
6. Plan the availability of resources in detail. [PA149.IG101.SP102.SubP106]

SP 1.3 Establish Validation Procedures and Criteria

Establish and maintain procedures and criteria for validation.

[PA149.IG101.SP103]

Validation procedures and criteria are defined to ensure that the product or product component will fulfill its intended use when placed in its intended environment. Acceptance test cases and procedures may meet the need for validation procedures. [PA149.IG101.SP103.N101]

The validation procedures and criteria include test and evaluation of maintenance, training, and support services. [PA149.IG101.SP103.N102]

Examples of sources for validation criteria include the following: [PA149.IG101.SP103.N103]

- Product and product-component requirements
- Standards
- Customer acceptance criteria
- Environmental performance
- Thresholds of performance deviation

Typical Work Products

1. Validation procedures [PA149.IG101.SP103.W101]
2. Validation criteria [PA149.IG101.SP103.W102]
3. Test and evaluation procedures for maintenance, training, and support [PA149.IG101.SP103.W103]

Subpractices

1. Review the product requirements to ensure that issues affecting validation of the product or product component are identified and resolved. [PA149.IG101.SP103.SubP101]
2. Document the environment, operational scenario, procedures, inputs, outputs, and criteria for the validation of the selected product or product component. [PA149.IG101.SP103.SubP102]
3. Assess the design as it matures in the context of the validation environment to identify validation issues. [PA149.IG101.SP103.SubP103]

SG 2 Validate Product or Product Components

The product or product components are validated to ensure that they are suitable for use in their intended operating environment. *[PA149.IG102]*

The validation methods, procedures, and criteria are used to validate the selected products and product components and any associated maintenance, training, and support services using the appropriate validation environment. [PA149.IG102.N102]

SP 2.1 Perform Validation

Perform validation on the selected products and product components. *[PA149.IG102.SP101]*

To be acceptable to users, a product or product component must perform as expected in its intended operational environment.

[PA149.IG102.SP101.N101]

Validation activities are performed and the resulting data are collected according to the established methods, procedures, and criteria. [PA149.IG102.SP101.N102]

The as-run validation procedures should be documented and the deviations occurring during the execution should be noted, as appropriate. [PA149.IG102.SP101.N103]

(For users of the continuous representation, this is a capability level 1 specific practice. Validation processes at capability level 1 or 2 may not include procedures and criteria, which are created in the Establish Validation Procedures and Criteria specific practice at capability level 3. When there are no procedures or criteria established, use the methods established by the Select Products for Validation specific practice to accomplish capability level 1 performance.) [PA149.IG102.SP101.N104]

Typical Work Products

1. Validation reports [PA149.IG102.SP101.W101]
2. Validation results [PA149.IG102.SP101.W102]
3. Validation cross-reference matrix [PA149.IG102.SP101.W103]
4. As-run procedures log [PA149.IG102.SP101.W104]
5. Operational demonstrations [PA149.IG102.SP101.W105]

SP 2.2 Analyze Validation Results

Analyze the results of the validation activities and identify issues.
[PA149.IG102.SP102]

The data resulting from validation tests, inspections, demonstrations, or evaluations are analyzed against the defined validation criteria. Analysis reports indicate whether the needs were met; in the case of deficiencies, these reports document the degree of success or failure and categorize probable cause of failure. The collected test, inspection, or review results are compared with established evaluation criteria to determine whether to proceed or to address requirements or design issues in the requirements development or technical solution processes. [PA149.IG102.SP102.N101]

Analysis reports or as-run validation documentation may also indicate that bad test results are due to a validation procedure problem or a validation environment problem. [PA149.IG102.SP102.N102]

Typical Work Products

1. Validation deficiency reports [PA149.IG102.SP102.W101]
2. Validation issues [PA149.IG102.SP102.W102]

3. Procedure change request [PA149.IG102.SP102.W103]

Subpractices

1. Compare actual results to expected results. [PA149.IG102.SP102.SubP101]
2. Based on the established validation criteria, identify products and product components that do not perform suitably in their intended operating environments, or identify problems with the methods, criteria, and/or environment. [PA149.IG102.SP102.SubP102]
3. Analyze the validation data for defects. [PA149.IG102.SP102.SubP103]
4. Record the results of the analysis and identify issues. [PA149.IG102.SP102.SubP104]
5. Use validation results to compare actual measurements and performance to intended use or operational need. [PA149.IG102.SP102.SubP105]

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the validation process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for selecting products and product components for validation; for selecting validation methods; and for establishing and maintaining validation procedures, criteria, and environments that ensure the products and product components satisfy user needs in their intended operating environment. [PA149.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined validation process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the validation process. *[GP104]*

Elaboration:

Typically, this plan for performing the validation process is included in (or referenced by) the project plan, which is described in the Project Planning process area. [PA149.EL116]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the validation process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Special facilities may be required for validating the product or product components. When necessary, the facilities required for validation are developed or purchased. [PA149.EL111]

Examples of other resources provided include the following tools: [PA149.EL103]

- Test management tools
- Test-case generators
- Test-coverage analyzers
- Simulators
- Load, stress, and performance tools

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the validation process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the validation process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA149.EL104]

- Application domain
- Validation principles, standards, and methods
- Intended-use environment

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the validation process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA149.EL105]

- Lists of products and product components selected for validation
- Validation methods, procedures, and criteria
- Validation reports

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the validation process as planned. *[GP124]*

Elaboration:

Select relevant stakeholders from customers, end users, developers, producers, testers, suppliers, marketers, maintainers, disposal personnel, and others who may be affected by, or may affect, the product as well as the process. [PA149.EL113]

Examples of activities for stakeholder involvement include the following: [PA149.EL114]

- Selecting the products and product components to be validated
- Establishing the validation methods, procedures, and criteria
- Reviewing results of product and product-component validation and resolving issues
- Resolving issues with the customers or end users

Issues with the customers or end users are resolved particularly when there are significant deviations from their baseline needs for the following: [PA149.EL115]

- Waivers on the contract or agreement (what, when, and for which products, services, or manufactured products)
- Additional in-depth studies, trials, tests, or evaluations
- Possible changes in the contracts or agreements

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the validation process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA149.EL109]

- Number of validation activities completed (planned versus actual)
- Validation problem report trends (e.g., number written and number closed)
- Validation problem report aging (i.e., how long each problem report has been open)

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the validation process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the validation process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA149.EL110]

- Selecting the products and product components to be validated
- Establishing and maintaining validation methods, procedures, and criteria
- Validating products or product components

Examples of work products reviewed include the following: [PA149.EL112]

- Validation methods, procedures, and criteria

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the validation process with higher level management and resolve issues. *[GP112]*

ORGANIZATIONAL PROCESS FOCUS

Maturity Level 3

Purpose

The purpose of Organizational Process Focus is to plan and implement organizational process improvement based on a thorough understanding of the current strengths and weaknesses of the organization's processes and process assets. [PA152]

Introductory Notes

The organization's processes include the organization's set of standard processes and the defined processes that are tailored from them. The organizational process assets are used to establish, maintain, implement, and improve the defined processes. See Chapter 3 for an explanation of how "organizational process assets" is used in the CMMI Product Suite. [PA152.N101]

Candidate improvements to the organizational process assets are obtained from various sources, including measurement of the processes, lessons learned in implementing the processes, results of process appraisals, results of product evaluation activities, results of benchmarking against other organizations' processes, and recommendations from other improvement initiatives in the organization. [PA152.N102]

Process improvement occurs within the context of the organization's needs and is used to address the organization's objectives. The organization encourages participation in process-improvement activities by those who will perform the process. The responsibility for facilitating and managing the organization's process-improvement activities, including coordinating the participation of others, is typically assigned to a process group. The organization provides the long-term commitment and resources required to sponsor this group. [PA152.N103]

Careful planning is required to ensure that process-improvement efforts across the organization are adequately managed and implemented. The organization's planning for process-improvement results in a process-improvement plan. The organization's process-improvement plan will address appraisal planning, process action planning, pilot planning, and deployment planning. Appraisal plans describe the appraisal timeline and schedule, the scope of the appraisal, the resources required to perform the appraisal, the reference model against which the appraisal will be performed, and the logistics for the appraisal. Process action plans usually result from appraisals and document how specific improvements targeting the weaknesses uncovered by an appraisal will be implemented. In cases in which it is determined that the improvement described in the process action plan should be tested on a small group before deploying it across the organization, a pilot plan is generated. Finally, when the improvement is to be deployed, a deployment plan is used. This plan describes when and how the improvement will be deployed across the organization. [PA152.N104]

Related Process Areas

Refer to the Organizational Process Definition process area for more information about the organizational process assets. [PA152.R101]

Specific and Generic Goals

SG 1 **Determine Process-Improvement Opportunities** [PA152.IG101]

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

SG 2 **Plan and Implement Process-Improvement Activities** [PA152.IG102]

Improvements are planned and implemented, organizational process assets are deployed, and process-related experiences are incorporated into the organizational process assets.

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Determine Process-Improvement Opportunities [PA152.IG101]
- SP 1.1 Establish Organizational Process Needs
- SP 1.2 Appraise the Organization's Processes

SP 1.3 Identify the Organization's Process Improvements

SG 2 Plan and Implement Process-Improvement Activities [PA152.IG102]

SP 2.1 Establish Process Action Plans
SP 2.2 Implement Process Action Plans
SP 2.3 Deploy Organizational Process Assets
SP 2.4 Incorporate Process-Related Experiences into the Organizational Process Assets

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 3.1	(AB 1)	Establish a Defined Process
GP 2.2	(AB 2)	Plan the Process
GP 2.3	(AB 3)	Provide Resources
GP 2.4	(AB 4)	Assign Responsibility
GP 2.5	(AB 5)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 3.2	(DI 4)	Collect Improvement Information
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

Specific Practices by Goal

SG 1 Determine Process-Improvement Opportunities

Strengths, weaknesses, and improvement opportunities for the organization's processes are identified periodically and as needed. [PA152.IG101]

Strengths, weaknesses, and improvement opportunities may be determined relative to a process standard or model such as a CMMI model or International Organization for Standardization (ISO) standard. The process improvements should be selected specifically to address the organization's needs. [PA152.IG101.N101]

SP 1.1 Establish Organizational Process Needs

Establish and maintain the description of the process needs and objectives for the organization. [PA152.IG101.SP101]

For Integrated Product and Process Development

Integrated processes that emphasize parallel rather than serial development are a cornerstone of IPPD implementation. Product development processes and product-related life-cycle processes, such as the manufacturing process development and the support process development processes, are conducted concurrently. Such integrated processes need to accommodate the information provided by stakeholders representing all phases of the product life cycle from both business and technical functions. Processes for effective teamwork will also be needed. [PA152.IG101.SP101.AMP101]

For Integrated Product and Process Development

Examples of processes for effective teamwork include the following: [PA152.IG101.SP101.AMP102]

- *Communications*
- *Collaborative decision making*
- *Issue resolution*
- *Team building*

The organization's processes operate in a business context that must be understood. The organization's business objectives, needs, and constraints determine the needs and objectives for the organization's processes. Typically, the issues related to financial, technological, quality, human resource, and marketing are important process considerations. [PA152.IG101.SP101.N101]

The organization's process needs and objectives cover aspects that include the following: [PA152.IG101.SP101.N102]

- Characteristics of the processes
- Process performance objectives, such as time to market and product quality
- Process effectiveness

Typical Work Products

1. Organization's process needs and objectives [PA152.IG101.SP101.W101]

Subpractices

1. Identify the policies, standards, and business objectives that are applicable to the organization's processes. [PA152.IG101.SP101.SubP101]
2. Examine relevant process standards and models for best practices. [PA152.IG101.SP101.SubP102]
3. Determine the organization's process performance objectives. [PA152.IG101.SP101.SubP103]

Process performance objectives may be expressed in quantitative or qualitative terms. [PA152.IG101.SP101.SubP103.N101]

Examples of process performance objectives include the following: [PA152.IG101.SP101.SubP103.N102]

- Cycle time
- Defect removal rates
- Productivity

4. Define the essential characteristics of the organization's processes. [PA152.IG101.SP101.SubP104]

   The essential characteristics of the organization's processes are determined based on the following: [PA152.IG101.SP101.SubP104.N101]

   - Processes currently being used in the organization
   - Process and product standards imposed by the organization
   - Process and product standards commonly imposed by customers of the organization

   Examples of process characteristics include the following: [PA152.IG101.SP101.SubP104.N102]

   - Level of detail used to describe the processes
   - Process notation used
   - Granularity of the processes

5. Document the organization's process needs and objectives. [PA152.IG101.SP101.SubP105]

6. Revise the organization's process needs and objectives as needed. [PA152.IG101.SP101.SubP106]

SP 1.2 Appraise the Organization's Processes

Appraise the processes of the organization periodically and as needed to maintain an understanding of their strengths and weaknesses. *[PA152.IG101.SP102]*

Process appraisals may be performed for the following reasons: [PA152.IG101.SP102.N101]

- To identify processes that should be improved
- To confirm progress and make the benefits of process improvement visible
- To satisfy the needs of a customer-supplier relationship
- To motivate and facilitate buy-in

The buy-in gained during a process appraisal can be eroded significantly if it is not followed by an appraisal-based action plan. [PA152.IG101.SP102.N102]

Typical Work Products

1. Plans for the organization's process appraisals [PA152.IG101.SP102.W101]
2. Appraisal findings that address strengths and weaknesses of the organization's processes [PA152.IG101.SP102.W102]
3. Improvement recommendations for the organization's processes [PA152.IG101.SP102.W103]

Subpractices

1. Obtain sponsorship of the process appraisal from senior management. [PA152.IG101.SP102.SubP101]

   Senior-management sponsorship includes the commitment to have the organization's managers and staff participate in the process appraisal and to provide the resources and funding to analyze and communicate the findings of the appraisal. [PA152.IG101.SP102.SubP101.N101]

2. Define the scope of the process appraisal. [PA152.IG101.SP102.SubP102]

   Process appraisals may be performed on the entire organization or may be performed on a smaller part of an organization such as a single project or business area. [PA152.IG101.SP102.SubP102.N101]

   The scope of the process appraisal addresses the following: [PA152.IG101.SP102.SubP102.N102]

   - Definition of the organization (e.g., sites or business areas) that will be covered by the appraisal
   - Identification of the project and support functions that will represent the organization in the appraisal
   - Processes that will be appraised

3. Determine the method and criteria for process appraisal. [PA152.IG101.SP102.SubP103]

   Process appraisals can occur in many forms. Process appraisals should address the needs and objectives of the organization, which may change over time. For example, the appraisal may be based on a process model, such as a CMMI model, or on a national or international standard, such as ISO 9001. The appraisals may also be based on a benchmark comparison with other organizations. The appraisal method may assume a variety of characteristics in terms of time and effort expended, makeup of the appraisal team, and the method and depth of investigation. [PA152.IG101.SP102.SubP103.N101]

4. Plan, schedule, and prepare for the process appraisal. [PA152.IG101.SP102.SubP104]

5. Conduct the process appraisal. [PA152.IG101.SP102.SubP105]

6. Document and deliver the appraisal's activities and findings. [PA152.IG101.SP102.SubP106]

SP 1.3 Identify the Organization's Process Improvements

Identify improvements to the organization's processes and process assets. *[PA152.IG101.SP103]*

Typical Work Products

1. Analysis of candidate process improvements [PA152.IG101.SP103.W101]

2. Identification of improvements for the organization's processes [PA152.IG101.SP103.W102]

Subpractices

1. Determine candidate process improvements. [PA152.IG101.SP103.SubP101]

   Candidate process improvements are typically determined by doing the following: [PA152.IG101.SP103.SubP101.N101]

   - Measure the processes and analyze the measurement results
   - Review the processes for effectiveness and suitability
   - Review the lessons learned from tailoring the organization's set of standard processes
   - Review the lessons learned from implementing the processes
   - Review process-improvement proposals submitted by the organization's managers and staff, and other relevant stakeholders
   - Solicit inputs on process improvements from the senior management and leaders in the organization
   - Examine the results of process appraisals and other process-related reviews
   - Review results of other organization improvement initiatives

2. Prioritize the candidate process improvements. [PA152.IG101.SP103.SubP102]

   Criteria for prioritization are as follows: [PA152.IG101.SP103.SubP102.N101]

   - Consider the estimated cost and effort to implement the process improvements
   - Appraise the expected improvement against the organization's improvement objectives and priorities
   - Determine the potential barriers to the process improvements and develop strategies for overcoming these barriers

Examples of techniques to help determine and prioritize the possible improvements to be implemented include the following: [PA152.IG101.SP103.SubP102.N102]

- A gap analysis that compares current conditions in the organization with optimal conditions
- Force-field analysis of potential improvements to identify potential barriers and strategies for overcoming those barriers
- Cause-and-effect analyses to provide information on the potential effects of different improvements that can then be compared

3. Identify and document the process improvements that will be implemented. [PA152.IG101.SP103.SubP103]
4. Revise the list of planned process improvements to keep it current. [PA152.IG101.SP103.SubP104]

SG 2 Plan and Implement Process-Improvement Activities

Improvements are planned and implemented, organizational process assets are deployed, and process-related experiences are incorporated into the organizational process assets. *[PA152.IG102]*

Successful implementation of improvements requires participation in the process definition and improvement activities by process owners, those performing the process, and support organizations. [PA152.IG102.N101]

SP 2.1 Establish Process Action Plans

Establish and maintain process action plans to address improvements to the organization's processes and process assets. *[PA152.IG102.SP101]*

Establishing and maintaining process action plans typically involves the following roles: [PA152.IG102.SP101.N101]

- Management steering committees to set strategies and oversee process-improvement activities
- Process group staff to facilitate and manage the process-improvement activities
- Process action teams to define and implement the improvement
- Process owners to manage the deployment
- Practitioners to perform the process

This involvement helps to obtain buy-in on the process improvements and increases the likelihood of effective deployment. [PA152.IG102.SP101.N102]

Process action plans are detailed implementation plans. These plans differ from the organization's process-improvement plan in that they are plans targeting specific improvements that have been defined to address weaknesses usually uncovered by appraisals. [PA152.IG102.SP101.N103]

Typical Work Products

1. Organization's approved process action plans [PA152.IG102.SP101.W101]

Subpractices

1. Identify strategies, approaches, and actions to address the identified process improvements. [PA152.IG102.SP101.SubP101]

   New, unproven, and major changes are piloted before they are incorporated into normal use. [PA152.IG102.SP101.SubP101.N101]

2. Establish process action teams to implement the actions. [PA152.IG102.SP101.SubP102]

   The teams and people performing the process-improvement actions are called "process action teams." Process action teams typically include process owners and those who perform the process. [PA152.IG102.SP101.SubP102.N101]

3. Document process action plans. [PA152.IG102.SP101.SubP103]

   Process action plans typically cover the following: [PA152.IG102.SP101.SubP103.N101]

   - Process-improvement infrastructure
   - Process-improvement objectives
   - Process improvements that will be addressed
   - Procedures for planning and tracking process actions
   - Strategies for piloting and implementing the process actions
   - Responsibility and authority for implementing the process actions
   - Resources, schedules, and assignments for implementing the process actions
   - Methods for determining the effectiveness of the process actions
   - Risks associated with process action plans

4. Review and negotiate process action plans with relevant stakeholders. [PA152.IG102.SP101.SubP104]

5. Review process action plans as necessary. [PA152.IG102.SP101.SubP105]

SP 2.2 Implement Process Action Plans

Implement process action plans across the organization.

[PA152.IG102.SP102]

Typical Work Products

1. Commitments among the various process action teams [PA152.IG102.SP102.W101]
2. Status and results of implementing process action plans [PA152.IG102.SP102.W102]
3. Plans for pilots [PA152.IG102.SP102.W103]

Subpractices

1. Make process action plans readily available to relevant stakeholders. [PA152.IG102.SP102.SubP101]
2. Negotiate and document commitments among the process action teams and revise their process action plans as necessary. [PA152.IG102.SP102.SubP102]
3. Track progress and commitments against process action plans. [PA152.IG102.SP102.SubP103]
4. Conduct joint reviews with the process action teams and relevant stakeholders to monitor the progress and results of the process actions. [PA152.IG102.SP102.SubP104]
5. Plan pilots needed to test selected process improvements. [PA152.IG102.SP102.SubP105]
6. Review the activities and work products of process action teams. [PA152.IG102.SP102.SubP106]
7. Identify, document, and track to closure issues in implementing process action plans. [PA152.IG102.SP102.SubP107]
8. Ensure that the results of implementing process action plans satisfy the organization's process-improvement objectives. [PA152.IG102.SP102.SubP108]

SP 2.3 Deploy Organizational Process Assets

Deploy organizational process assets across the organization.

[PA152.IG102.SP103]

Deployment of organizational process assets or of changes to organizational process assets should be performed in an orderly manner. Some organizational process assets or changes to organizational process assets may not be appropriate for implementation in some parts of the organization (because of customer requirements or the current lifecycle phase being implemented, for example). It is therefore important that those that are or will be executing the process, as well as other organization functions (such as training and quality assurance) be involved in the deployment as necessary. [PA152.IG102.SP103.N101]

Refer to the Organizational Process Definition process area for more information about how the deployment of organizational process assets is supported and enabled by the organization's process asset library.

[PA152.IG102.SP103.N101.R101]

Typical Work Products

1. Plans for deploying the organizational process assets and changes to organizational process assets [PA152.IG102.SP103.W101]
2. Training materials for deploying the organizational process assets and changes to organizational process assets [PA152.IG102.SP103.W102]
3. Documentation of changes to the organizational process assets [PA152.IG102.SP103.W103]
4. Support materials for deploying the organizational process assets and changes to organizational process assets [PA152.IG102.SP103.W104]

Subpractices

1. Deploy organizational process assets and associated methods and tools. [PA152.IG102.SP103.SubP101]

   Typical activities performed as a part of this deployment include the following: [PA152.IG102.SP103.SubP101.N101]

   - Planning the deployment
   - Identifying the organizational process assets that should be adopted by those who will be performing the process
   - Ensuring that training is available for the organizational process assets that are being deployed
   - Identifying the support resources (e.g., tools) needed to transition the deployed organizational process assets
   - Determining the schedule for deploying the organizational process assets

   Refer to the Organizational Training process area for more information about coordination of training.

   [PA152.IG102.SP103.SubP101.N101.R101]

2. Deploy the changes that were made to the organizational process assets. [PA152.IG102.SP103.SubP102]

   Typical activities performed as a part of this deployment include the following: [PA152.IG102.SP103.SubP102.N101]

   - Planning the deployment
   - Determining which changes are appropriate for those that are or will be performing the process
   - Determining the time frame for deploying the changes
   - Arranging for the associated support needed to successfully transition the changes

3. Document the changes to the organizational process assets. [PA152.IG102.SP103.SubP103]

   The documentation of changes is used to understand the relationship of the changes to resulting changes in process performance and results. [PA152.IG102.SP103.SubP103.N101]

4. Provide guidance and consultation on the use of the organizational process assets. [PA152.IG102.SP103.SubP104]

SP 2.4 Incorporate Process-Related Experiences into the Organizational Process Assets

Incorporate process-related work products, measures, and improvement information derived from planning and performing the process into the organizational process assets. *[PA152.IG102.SP104]*

Typical Work Products

1. Process-improvement proposals [PA152.IG102.SP104.W101]
2. Process lessons learned [PA152.IG102.SP104.W102]
3. Measurements on the organizational process assets [PA152.IG102.SP104.W103]
4. Improvement recommendations for the organizational process assets [PA152.IG102.SP104.W104]
5. Records of the organization's process-improvement activities [PA152.IG102.SP104.W105]
6. Information on the organizational process assets and improvements to them [PA152.IG102.SP104.W106]

Subpractices

1. Conduct periodic reviews of the effectiveness and suitability of the organization's set of standard processes and related organizational process assets relative to the organization's business objectives. [PA152.IG102.SP104.SubP101]

2. Obtain feedback about the use of the organizational process assets. [PA152.IG102.SP104.SubP102]

3. Derive lessons learned from defining, piloting, implementing, and deploying the organizational process assets. [PA152.IG102.SP104.SubP103]

4. Make lessons learned available to the people in the organization as appropriate. [PA152.IG102.SP104.SubP104]

   Actions may have to be taken to ensure that lessons learned are used appropriately. [PA152.IG102.SP104.SubP104.N101]

   Examples of inappropriate use of lessons learned include the following: [PA152.IG102.SP104.SubP104.N102]

   - Evaluating the performance of people
   - Judging process performance or results

   Examples of ways to prevent inappropriate use of lessons learned include the following: [PA152.IG102.SP104.SubP104.N103]

   - Controlling access to the lessons learned
   - Educating people about the appropriate use of lessons learned

5. Analyze the organization's common set of measures. [PA152.IG102.SP104.SubP105]

   Refer to the Measurement and Analysis process area for more information about analyzing measures. *[PA152.IG102.SP104.SubP105.R101]*

   Refer to the Organizational Process Definition process area for more information about establishing an organizational measurement repository, including common measures. *[PA152.IG102.SP104.SubP105.R102]*

6. Appraise the processes, methods, and tools in use in the organization and develop recommendations for improving the organizational process assets. [PA152.IG102.SP104.SubP106]

   This appraisal typically includes the following: [PA152.IG102.SP104.SubP106.N101]

   - Determining which of the processes, methods, and tools are of potential use to other parts of the organization
   - Appraising the quality and effectiveness of the organizational process assets

- Identifying candidate improvements to the organizational process assets
- Determining compliance with the organization's set of standard processes and tailoring guidelines

7. Make the best use of the organization's processes, methods, and tools available to the people in the organization as appropriate. [PA152.IG102.SP104.SubP107]

8. Manage process-improvement proposals. [PA152.IG102.SP104.SubP108]

   The activities for managing process-improvement proposals typically include the following: [PA152.IG102.SP104.SubP108.N101]

   - Soliciting process-improvement proposals
   - Collecting process-improvement proposals
   - Reviewing the process-improvement proposals
   - Selecting the process-improvement proposals that will be implemented
   - Tracking the implementation of the process-improvement proposals

   Process-improvement proposals are documented as process change requests or problem reports, as appropriate. [PA152.IG102.SP104.SubP108.N102]

   Some process-improvement proposals may be incorporated into the organization's process action plans. [PA152.IG102.SP104.SubP108.N103]

9. Establish and maintain records of the organization's process-improvement activities. [PA152.IG102.SP104.SubP109]

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the organizational process focus process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for determining process-improvement opportunities for the processes being used and for planning and implementing process-improvement activities across the organization. [PA152.EL101]

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined organizational process focus process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the organizational process focus process. *[GP104]*

Elaboration:

The plan for performing the organizational process focus process, which is often called "the process-improvement plan," differs from the process action plans described in specific practices in this process area. The plan called for in this generic practice addresses the comprehensive planning for all of the specific practices in this process area, from the establishment of organizational process needs all the way through to the incorporation of process-related experiences into the organizational process assets. [PA152.EL103]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the organizational process focus process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Examples of resources provided include the following tools: [PA152.EL106]

- Database management systems
- Process-improvement tools
- Web page builders and browsers
- Groupware
- Quality-improvement tools (e.g., quality-improvement tools, cause-and-effect diagrams, affinity diagrams, Pareto charts)

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the organizational process focus process. *[GP106]*

Elaboration:

Two groups are typically established and assigned responsibility for process improvement: (1) a management steering committee for process improvement to provide senior-management sponsorship; and (2) a process group to facilitate and manage the process-improvement activities. [PA152.EL120]

GP 2.5 (AB 5) Train People

Train the people performing or supporting the organizational process focus process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA152.EL107]

- CMMI and other process and process-improvement reference models
- Planning and managing process improvement
- Tools, methods, and analysis techniques
- Process modeling
- Facilitation techniques
- Change management

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the organizational process focus process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA152.EL108]

- Process-improvement proposals
- Organization's approved process action plans
- Training materials for deploying organizational process assets
- Plans for the organization's process appraisals

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the organizational process focus process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include the following: [PA152.EL119]

- Coordinating and collaborating on process-improvement activities with process owners, those that are or will be performing the process, and support organizations (e.g., training staff and quality assurance representatives)
- Establishing the organizational process needs and objectives
- Appraising the organization's processes
- Implementing process action plans
- Coordinating and collaborating on the execution of pilots to test selected improvements
- Deploying organizational process assets and changes to organizational process assets
- Communicating the plans, status, activities, and results related to the implementation of process-improvement activities

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the organizational process focus process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA152.EL113]

- Number of process-improvement proposals submitted, accepted, or implemented
- CMMI maturity level or capability level

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the organizational process focus process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational process focus process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA152.EL115]

- Determining process-improvement opportunities
- Planning and coordinating process-improvement activities

Examples of work products reviewed include the following: [PA152.EL118]

- Process-improvement plans
- Process action plans
- Plans for the organization's process appraisals

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the organizational process focus process with higher level management and resolve issues. *[GP112]*

Elaboration:

These reviews are typically in the form of a briefing presented to the management steering committee by the process group and the process action teams. [PA152.EL116]

Examples of presentation topics include the following: [PA152.EL121]

- Status of improvements being developed by process action teams
- Results of pilots
- Results of deployments
- Schedule status for achieving significant milestones (e.g., readiness for an appraisal, or progress towards achieving a targeted organizational maturity level or capability level profile)

ORGANIZATIONAL PROCESS DEFINITION

Maturity Level 3

Purpose

The purpose of Organizational Process Definition is to establish and maintain a usable set of organizational process assets. [PA153]

Introductory Notes

Organizational process assets enable consistent process performance across the organization and provide a basis for cumulative, long-term benefits to the organization. See Chapter 3 for an explanation of how "organizational process assets" is used in the CMMI Product Suite. [PA153.N101]

The organization's process asset library is a collection of items maintained by the organization for use by the people and projects of the organization. This collection of items includes descriptions of processes and process elements, descriptions of life-cycle models, process tailoring guidelines, process-related documentation, and data. The organization's process asset library supports organizational learning and process improvement by allowing the sharing of best practices and lessons learned across the organization. [PA153.N103]

The organization's set of standard processes is tailored by projects to create their defined processes. The other organizational process assets are used to support tailoring as well as the implementation of the defined processes. [PA153.N104]

A standard process is composed of other processes or process elements. A process element is the fundamental (e.g., atomic) unit of process definition and describes the activities and tasks to consistently perform work. Process architecture provides rules for connecting the process elements of a standard process. The organization's set of standard processes may include multiple process architectures. [PA153.N105]

See the definitions of "standard process" and "process element" in Appendix C, the glossary. See Chapter 3 for an explanation of how "process architecture" is used in the CMMI Product Suite. [PA153.N107]

The organizational process assets may be organized in many ways, depending on the implementation of the Organizational Process Definition process area. Examples include the following: [PA153.N106]

- Descriptions of life-cycle models may be documented as part of the organization's set of standard processes, or they may be documented separately.
- The organization's set of standard processes may be stored in the organization's process asset library, or they may be stored separately.
- A single repository may contain both the measurements and the process-related documentation, or they may be stored separately.

Related Process Areas

Refer to the Organizational Process Focus process area for more information about organizational process-related matters. [PA153.R101]

Specific and Generic Goals

SG 1 Establish Organizational Process Assets [PA153.IG101]

A set of organizational process assets is established and maintained.

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Establish Organizational Process Assets [PA153.IG101]

SP 1.1	Establish Standard Processes
SP 1.2	Establish Life-Cycle Model Descriptions
SP 1.3	Establish Tailoring Criteria and Guidelines
SP 1.4	Establish the Organization's Measurement Repository
SP 1.5	Establish the Organization's Process Asset Library

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 3.1	(AB 1)	Establish a Defined Process
GP 2.2	(AB 2)	Plan the Process
GP 2.3	(AB 3)	Provide Resources
GP 2.4	(AB 4)	Assign Responsibility
GP 2.5	(AB 5)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 3.2	(DI 4)	Collect Improvement Information

GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

Specific Practices by Goal

SG 1 Establish Organizational Process Assets

A set of organizational process assets is established and maintained. *[PA153.IG101]*

For Integrated Product and Process Development

Integrated processes that emphasize parallel rather than serial development are a cornerstone of IPPD implementation. Product development processes and product-related life-cycle processes, such as the manufacturing process development and the support process development processes, are conducted concurrently. Such integrated processes should accommodate the information provided by stakeholders representing all phases of the product life cycle from both business and technical functions. Processes for effective teamwork are also needed. *[PA153.IG101.AMP101]*

SP 1.1 Establish Standard Processes

Establish and maintain the organization's set of standard processes. *[PA153.IG101.SP101]*

For Integrated Product and Process Development

In an IPPD environment, the organization's shared vision is included in the organizational process assets.

[PA153.IG101.SP101.AMP101]

Standard processes may be defined at multiple levels in an enterprise and they may be related in a hierarchical manner. For example, an enterprise may have a set of standard processes that is tailored by individual organizations (e.g., a division or site) in the enterprise to establish their set of standard processes. The set of standard processes may also be tailored for each of the organization's business areas or product lines. Thus "the organization's set of standard processes" can refer to the standard processes established at the organization level and standard processes that may be established at lower levels, although some organizations may only have a single level of standard processes. See the definition of "standard process" in Appendix C, the glossary. See Chapter 3 for an explanation of how "organization's set of standard processes" is used in the CMMI Product Suite. [PA153.IG101.SP101.N101]

Multiple standard processes may be needed to address the needs of different application domains, life-cycle models, methodologies, and tools. The organization's set of standard processes contains process elements (e.g., a work product size-estimating element) that may be interconnected according to one or more process architectures that describe the relationships among these process elements. Processes may be composed of other processes or process elements. [PA153.IG101.SP101.N102]

The organization's set of standard processes typically includes technical, management, administrative, support, and organizational processes. [PA153.IG101.SP101.N103]

The organization's set of standard processes should collectively cover all processes needed by the organization and projects, including those processes addressed by the process areas at Maturity Level 2. [PA153.IG101.SP101.N104]

Typical Work Products

1. Organization's set of standard processes [PA153.IG101.SP101.W101]

Subpractices

1. Decompose each standard process into constituent process elements to the detail needed to understand and describe the process. [PA153.IG101.SP101.SubP101]

   Each process element covers a bounded and closely related set of activities. The descriptions of the process elements may be templates to be filled in, fragments to be completed, abstractions to be refined, or complete descriptions to be tailored or used unmodified. These elements are described in sufficient detail such that the process, when fully defined, can be consistently performed by appropriately trained and skilled people. [PA153.IG101.SP101.SubP101.N101]

   Examples of process elements include the following: [PA153.IG101.SP101.SubP101.N102]

   - Template for generating work product size estimates
   - Description of work product design methodology
   - Tailorable peer review methodology
   - Template for conduct of management reviews

2. Specify the critical attributes of each process element. [PA153.IG101.SP101.SubP102]

Examples of critical attributes include the following: [PA153.IG101.SP101.SubP102.N101]

- Process roles
- Applicable process and product standards
- Applicable procedures, methods, tools, and resources
- Process performance objectives
- Entry criteria
- Inputs
- Product and process measures to be collected and used
- Verification points (e.g., peer reviews)
- Outputs
- Interfaces
- Exit criteria

3. Specify the relationships of the process elements. [PA153.IG101.SP101.SubP103]

Examples of relationships include the following: [PA153.IG101.SP101.SubP103.N101]

- Ordering of the process elements
- Interfaces among the process elements
- Interfaces with external processes
- Interdependencies among the process elements

The rules for describing the relationships among process elements are referred to as "process architecture." The process architecture covers the essential requirements and guidelines. The detailed specifications of these relationships are covered in the descriptions of the defined processes that are tailored from the organization's set of standard processes. [PA153.IG101.SP101.SubP103.N102]

4. Ensure that the organization's set of standard processes adheres to applicable policies; process standards and models; and product standards. [PA153.IG101.SP101.SubP104]

Adherence to applicable process standards and models is typically demonstrated by developing a mapping from the organization's set of standard processes to the relevant process standards and models. In addition, this mapping will be a useful input to future appraisals. [PA153.IG101.SP101.SubP104.N101]

5. Ensure that the organization's set of standard processes satisfies the process needs and objectives of the organization. [PA153.IG101.SP101.SubP105]

Refer to the Organizational Process Focus process area for more information about establishing and maintaining the organization's process needs and objectives. *[PA153.IG101.SP101.SubP105.R101]*

6. Ensure that there is appropriate integration among the processes that are included in the organization's set of standard processes. [PA153.IG101.SP101.SubP106]

7. Document the organization's set of standard processes. [PA153.IG101.SP101.SubP107]

8. Conduct peer reviews on the organization's set of standard processes. [PA153.IG101.SP101.SubP108]

   Refer to the Verification process area for more information about peer review. *[PA153.IG101.SP101.SubP108.R101]*

9. Revise the organization's set of standard processes as necessary. [PA153.IG101.SP101.SubP109]

SP 1.2 Establish Life-Cycle Model Descriptions

Establish and maintain descriptions of the life-cycle models approved for use in the organization. *[PA153.IG101.SP102]*

Life-cycle models may be developed for a variety of customers or in a variety of situations, since one life-cycle model may not be appropriate for all situations. The organization may identify more than one life-cycle model for use. Typically, the organization needs both product and project life-cycle models, for the types of products that it produces and for defining the phases of the project. [PA153.IG101.SP102.N101]

Product life-cycle models partition the product life cycle into phases for which activities and requirements can be defined to promote a complete solution, from initiating development of the product to its ultimate disposal. [PA153.IG101.SP102.N102]

Typical Work Products

1. Descriptions of life-cycle models [PA153.IG101.SP102.W101]

Subpractices

1. Select life-cycle models based on the needs of projects and the organization. [PA153.IG101.SP102.SubP101]

For example, in the case of a development project, project life-cycle models include the following: [PA153.IG101.SP102.SubP101.N101]

- Waterfall
- Spiral
- Evolutionary
- Incremental
- Iterative

Examples of project characteristics that could affect the project life-cycle models include the following: [PA153.IG101.SP102.SubP101.N102]

- Size of the project
- Experience and familiarity of project staff in implementing the process
- Constraints such as cycle time and acceptable defect levels

2. Document the descriptions of the life-cycle models.
[PA153.IG101.SP102.SubP102]

   The life-cycle models may be documented as part of the organization's standard process descriptions or they may be documented separately.
[PA153.IG101.SP102.SubP102.N101]

3. Conduct peer reviews on the life-cycle models. [PA153.IG101.SP102.SubP103]

   Refer to the Verification process area for more information about conducting peer reviews. *[PA153.IG101.SP102.SubP103.R101]*

4. Revise the descriptions of the life-cycle models as necessary.
[PA153.IG101.SP102.SubP104]

SP 1.3 Establish Tailoring Criteria and Guidelines

Establish and maintain the tailoring criteria and guidelines for the organization's set of standard processes. *[PA153.IG101.SP103]*

For Integrated Product and Process Development

In creating the tailoring criteria and guidelines, include considerations for concurrent development and operating with integrated teams. For example, how one tailors the manufacturing process will be different depending on whether it is done serially after the product has been developed or in parallel with the development of the product, as in IPPD. Processes, such as resource allocation, will also be tailored differently if the project is operating with integrated teams.
[PA153.IG101.SP103.AMP101]

The tailoring criteria and guidelines describe the following: [PA153.IG101.SP103.N101]

- How the organization's set of standard processes and organizational process assets are used to create the defined processes
- Mandatory requirements that must be satisfied by the defined processes (e.g., the subset of the organizational process assets that are essential for any defined process)
- Options that can be exercised and criteria for selecting among the options
- Procedures that must be followed in performing and documenting process tailoring

Examples of reasons for tailoring include the following: [PA153.IG101.SP103.N102]

- Adapting the process for a new product line or host environment
- Customizing the process for a specific application or class of applications (e.g., initial development, maintenance, or creation of prototypes)
- Elaborating the process description so that the resulting defined process can be performed

Flexibility in tailoring and defining processes is balanced with ensuring appropriate consistency in the processes across the organization. Flexibility is needed to address contextual variables such as the domain; nature of the customer; cost, schedule, and quality tradeoffs; technical difficulty of the work; and experience of the people implementing the process. Consistency across the organization is needed so that organizational standards, objectives, and strategies are appropriately addressed, and process data and lessons learned can be shared. [PA153.IG101.SP103.N103]

Tailoring criteria and guidelines may allow for using a standard process "as is," with no tailoring. [PA153.IG101.SP103.N104]

Typical Work Products

1. Tailoring guidelines for the organization's set of standard processes [PA153.IG101.SP103.W101]

Subpractices

1. Specify the selection criteria and procedures for tailoring the organization's set of standard processes. [PA153.IG101.SP103.SubP101]

Examples of criteria and procedures include the following: [PA153.IG101.SP103.SubP101.N101]

- Criteria for selecting life-cycle models from those approved by the organization
- Criteria for selecting process elements from the organization's set of standard processes
- Procedures for tailoring the selected life-cycle models and process elements to accommodate specific process characteristics and needs

Examples of tailoring actions include the following: [PA153.IG101.SP103.SubP101.N102]

- Modifying a life-cycle model
- Combining elements of different life-cycle models
- Modifying process elements
- Replacing process elements
- Reordering process elements

2. Specify the standards for documenting the defined processes. [PA153.IG101.SP103.SubP102]
3. Specify the procedures for submitting and obtaining approval of waivers from the requirements of the organization's set of standard processes. [PA153.IG101.SP103.SubP103]
4. Document the tailoring guidelines for the organization's set of standard processes. [PA153.IG101.SP103.SubP104]
5. Conduct peer reviews on the tailoring guidelines. [PA153.IG101.SP103.SubP105]

   Refer to the Verification process area for more information about conducting peer reviews. *[PA153.IG101.SP103.SubP105.R101]*
6. Revise the tailoring guidelines as necessary. [PA153.IG101.SP103.SubP106]

SP 1.4 Establish the Organization's Measurement Repository

Establish and maintain the organization's measurement repository. *[PA153.IG101.SP104]*

Refer to the Use Organizational Process Assets for Planning Project Activities specific practice of the Integrated Project Management process area for more information about the use of the organization's measurement repository in planning project activities. *[PA153.IG101.SP104.R101]*

The repository contains both product and process measures that are related to the organization's set of standard processes. It also contains or refers to the information needed to understand and interpret the measures and assess them for reasonableness and applicability. For example, the definitions of the measures are used to compare similar measures from different processes. [PA153.IG101.SP104.N101]

Typical Work Products

1. Definition of the common set of product and process measures for the organization's set of standard processes [PA153.IG101.SP104.W101]
2. Design of the organization's measurement repository [PA153.IG101.SP104.W102]
3. Organization's measurement repository (i.e., the repository structure and support environment) [PA153.IG101.SP104.W103]
4. Organization's measurement data [PA153.IG101.SP104.W104]

Subpractices

1. Determine the organization's needs for storing, retrieving, and analyzing measurements. [PA153.IG101.SP104.SubP101]
2. Define a common set of process and product measures for the organization's set of standard processes. [PA153.IG101.SP104.SubP102]

   The measures in the common set are selected based on the organization's set of standard processes. The common set of measures may vary for different standard processes. [PA153.IG101.SP104.SubP102.N101]

   Operational definitions for the measures specify the procedures for collecting valid data and the point in the process where the data will be collected. [PA153.IG101.SP104.SubP102.N102]

   Examples of classes of commonly used measures include the following: [PA153.IG101.SP104.SubP102.N103]

   - Estimates of work product size (e.g., pages)
   - Estimates of effort and cost (e.g., person hours)
   - Actual measures of size, effort, and cost
   - Quality measures (e.g., number of defects found, severity of defects)
   - Peer review coverage
   - Test coverage
   - Reliability measures (e.g., mean time to failure)

   Refer to the Measurement and Analysis process area for more information about defining measures. *[PA153.IG101.SP104.SubP102.N103.R101]*

3. Design and implement the measurement repository.
[PA153.IG101.SP104.SubP103]

4. Specify the procedures for storing, updating, and retrieving measures. [PA153.IG101.SP104.SubP104]

5. Conduct peer reviews on the definitions of the common set of measures and the procedures for storing and retrieving measures.
[PA153.IG101.SP104.SubP105]

Refer to the Verification process area for more information about conducting peer reviews. *[PA153.IG101.SP104.SubP105.R101]*

6. Enter the specified measures into the repository.
[PA153.IG101.SP104.SubP106]

Refer to the Measurement and Analysis process area for more information about collecting and analyzing data.
[PA153.IG101.SP104.SubP106.R101]

7. Make the contents of the measurement repository available for use by the organization and projects as appropriate. [PA153.IG101.SP104.SubP107]

8. Revise the measurement repository, common set of measures, and procedures as the organization's needs change. [PA153.IG101.SP104.SubP108]

Examples of when the common set of measures may need to be revised include the following: [PA153.IG101.SP104.SubP108.N101]

- New processes are added
- Processes are revised and new product or process measures are needed
- Finer granularity of data is required
- Greater visibility into the process is required
- Measures are retired

SP 1.5 Establish the Organization's Process Asset Library

Establish and maintain the organization's process asset library.
[PA153.IG101.SP105]

Examples of items to be stored in the organization's process asset library include the following: [PA153.IG101.SP105.N101]

- Organizational policies
- Defined process descriptions
- Procedures (e.g., estimating procedure)
- Development plans
- Quality assurance plans
- Training materials
- Process aids (e.g., checklists)
- Lessons-learned reports

Typical Work Products

1. Design of the organization's process asset library [PA153.IG101.SP105.W101]
2. Organization's process asset library [PA153.IG101.SP105.W102]
3. Selected items to be included in the organization's process asset library [PA153.IG101.SP105.W103]
4. Catalog of items in the organization's process asset library [PA153.IG101.SP105.W104]

Subpractices

1. Design and implement the organization's process asset library, including the library structure and support environment. [PA153.IG101.SP105.SubP101]
2. Specify the criteria for including items in the library. [PA153.IG101.SP105.SubP102]

   The items are selected based primarily on their relationship to the organization's set of standard processes. [PA153.IG101.SP105.SubP102.N101]
3. Specify the procedures for storing and retrieving items. [PA153.IG101.SP105.SubP103]
4. Enter the selected items into the library and catalog them for easy reference and retrieval. [PA153.IG101.SP105.SubP104]
5. Make the items available for use by the projects. [PA153.IG101.SP105.SubP105]
6. Periodically review the use of each item and use the results to maintain the library contents. [PA153.IG101.SP105.SubP106]
7. Revise the organization's process asset library as necessary. [PA153.IG101.SP105.SubP107]

Examples of when the library may need to be revised include the following:
[PA153.IG101.SP105.SubP107.N101]

- New items are added
- Items are retired
- Current versions of items are changed

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the organizational process definition process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for establishing and maintaining a set of standard processes for use by the organization and making organizational process assets available across the organization.
[PA153.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined organizational process definition process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the organizational process definition process. *[GP104]*

Elaboration:

Typically, this plan for performing the organizational process definition process is a part of the organization's process-improvement plan.
[PA153.EL102]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the organizational process definition process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

A process group typically manages the organizational process definition activities. This group is typically staffed by a core of professionals whose primary responsibility is coordinating organizational process improvement. This group is supported by process owners and people with expertise in various disciplines such as the following: [PA153.EL108]

- Project management
- The appropriate engineering disciplines
- Configuration management
- Quality assurance

Examples of other resources provided include the following tools: [PA153.EL106]

- Database management systems
- Process modeling tools
- Web page builders and browsers

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the organizational process definition process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the organizational process definition process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA153.EL107]

- CMMI and other process and process-improvement reference models
- Planning, managing, and monitoring processes
- Process modeling and definition
- Developing a tailorable standard process

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the organizational process definition process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA153.EL103]

- Organization's set of standard processes
- Descriptions of the life-cycle models
- Tailoring guidelines for the organization's set of standard processes
- Definitions of the common set of product and process measures
- Organization's measurement data

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the organizational process definition process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include the following: [PA153.EL111]

- Reviewing the organization's set of standard processes
- Reviewing the organization's life-cycle models
- Resolving issues on the tailoring guidelines
- Assessing the definitions of the common set of process and product measures

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the organizational process definition process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA153.EL104]

- Percentage of projects using the process architectures and process elements of the organization's set of standard processes
- Defect density of each process element of the organization's set of standard processes

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the organizational process definition process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational process definition process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA153.EL105]

- Establishing organizational process assets

Examples of work products reviewed include the following: [PA153.EL110]

- Organization's set of standard processes
- Descriptions of the life-cycle models
- Tailoring guidelines for the organization's set of standard processes
- Organization's measurement data

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the organizational process definition process with higher level management and resolve issues. *[GP112]*

ORGANIZATIONAL TRAINING

Maturity Level 3

Purpose

The purpose of Organizational Training is to develop the skills and knowledge of people so they can perform their roles effectively and efficiently. [PA158]

Introductory Notes

Organizational Training includes training to support the organization's strategic business objectives and to meet the tactical training needs that are common across projects and support groups. Specific training needs identified by individual projects and support groups are handled at the project and support group level and are outside the scope of Organizational Training. Project and support groups are responsible for identifying and addressing their specific training needs. [PA158.N101]

Refer to the Project Planning process area for more information about the specific training needs identified by projects. [PA158.N101.R101]

An organizational training program involves the following: [PA158.N102]

- Identifying the training needed by the organization
- Obtaining and providing training to address those needs
- Establishing and maintaining training capability
- Establishing and maintaining training records
- Assessing training effectiveness

Effective training requires assessment of needs, planning, instructional design, and appropriate training media (e.g., workbooks, computer software), as well as a repository of training process data. As an organizational process, the main components of training include a managed training-development program, documented plans, personnel with appropriate mastery of specific disciplines and other areas of knowledge, and mechanisms for measuring the effectiveness of the training program. [PA158.N103]

The identification of process training needs is primarily based on the skills that are required to perform the organization's set of standard processes. [PA158.N104]

Refer to the Organizational Process Definition process area for more information about the organization's set of standard processes. *[PA158.N104.R101]*

Certain skills may be effectively and efficiently imparted through vehicles other than in-class training experiences (e.g., informal mentoring). Other skills require more formalized training vehicles, such as in a classroom, by Web-based training, through guided self study, or via a formalized on-the-job training program. The formal or informal training vehicles employed for each situation should be based on an assessment of the need for training and the performance gap to be addressed. The term "training" used throughout this process area is used broadly to include all of these learning options. [PA158.N105]

Success in training can be measured in terms of the availability of opportunities to acquire the skills and knowledge needed to perform new and ongoing enterprise activities. [PA158.N106]

Skills and knowledge may be technical, organizational, or contextual. Technical skills pertain to the ability to use the equipment, tools, materials, data, and processes required by a project or process. Organizational skills pertain to behavior within and according to the employee's organization structure, role and responsibilities, and general operating principles and methods. Contextual skills are the self-management, communication, and interpersonal abilities needed to successfully perform in the organizational and social context of the project and support groups. [PA158.N107]

The phrase "project and support groups" is used frequently in the text of the process area description to indicate an organization-level perspective. [PA158.N108]

Related Process Areas

Refer to the Organizational Process Definition process area for more information about the organization's process assets. *[PA158.R101]*

Refer to the Project Planning process area for more information about the specific training needs identified by projects. *[PA158.R102]*

Refer to the Decision Analysis and Resolution process area for how to apply decision-making criteria when determining training approaches. *[PA158.R103]*

Specific and Generic Goals

SG 1 **Establish an Organizational Training Capability** [PA158.IG101]

A training capability that supports the organization's management and technical roles is established and maintained.

SG 2 **Provide Necessary Training** [PA158.IG102]

Training necessary for individuals to perform their roles effectively is provided.

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Establish an Organizational Training Capability [PA158.IG101]

- SP 1.1 Establish the Strategic Training Needs
- SP 1.2 Determine Which Training Needs Are the Responsibility of the Organization
- SP 1.3 Establish an Organizational Training Tactical Plan
- SP 1.4 Establish Training Capability

SG 2 Provide Necessary Training [PA158.IG102]

- SP 2.1 Deliver Training
- SP 2.2 Establish Training Records
- SP 2.3 Assess Training Effectiveness

GG 3 Institutionalize a Defined Process [CL104.GL101]

- GP 2.1 (CO 1) Establish an Organizational Policy
- GP 3.1 (AB 1) Establish a Defined Process
- GP 2.2 (AB 2) Plan the Process
- GP 2.3 (AB 3) Provide Resources
- GP 2.4 (AB 4) Assign Responsibility
- GP 2.5 (AB 5) Train People
- GP 2.6 (DI 1) Manage Configurations
- GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders
- GP 2.8 (DI 3) Monitor and Control the Process
- GP 3.2 (DI 4) Collect Improvement Information
- GP 2.9 (VE 1) Objectively Evaluate Adherence
- GP 2.10 (VE 2) Review Status with Higher Level Management

Specific Practices by Goal

SG 1 Establish an Organizational Training Capability

A training capability that supports the organization's management and technical roles is established and maintained. [PA158.IG101]

The organization identifies the training required to develop the skills and knowledge necessary to perform enterprise activities. Once the needs are identified, a training program addressing those needs is developed. [PA158.IG101.N101]

For Integrated Product and Process Development

Cross-functional training, leadership training, interpersonal skills training, and training in the skills needed to integrate appropriate business and technical functions is needed by integrated team members. The potentially wider range of requirements and participant backgrounds may require relevant stakeholders who were not involved in requirements development to take cross training in the disciplines involved in product design in order to commit to requirements with a full understanding of the range of requirements and their interrelationships. [PA158.IG101.AMP101]

SP 1.1 Establish the Strategic Training Needs

Establish and maintain the strategic training needs of the organization. [PA158.IG101.SP101]

Examples of sources of strategic training needs include the following: [PA158.IG101.SP101.N101]

- Organization's standard processes
- Organization's strategic business plan
- Organization's process-improvement plan
- Enterprise-level initiatives
- Skill appraisals
- Risk analyses

Typical Work Products

1. Training needs [PA158.IG101.SP101.W101]
2. Assessment analysis [PA158.IG101.SP101.W102]

Subpractices

1. Analyze the organization's strategic business objectives and process-improvement plan to identify potential future training needs. [PA158.IG101.SP101.SubP101]

2. Document the strategic training needs of the organization. [PA158.IG101.SP101.SubP102]

> Examples of categories of training needs include (but are not limited to) the following: [PA158.IG101.SP101.SubP102.N101]
>
> - Process analysis and documentation
> - Engineering (e.g., requirements analysis, design, testing, configuration management, and quality assurance)
> - Selection and management of suppliers
> - Management (e.g., estimating, tracking, and risk management)

3. Determine the roles and skills needed to perform the organization's set of standard processes. [PA158.IG101.SP101.SubP103]
4. Document the training needed to perform the roles in the organization's set of standard processes. [PA158.IG101.SP101.SubP104]
5. Revise the organization's strategic needs and required training as necessary. [PA158.IG101.SP101.SubP105]

SP 1.2 Determine Which Training Needs Are the Responsibility of the Organization

Determine which training needs are the responsibility of the organization and which will be left to the individual project or support group. *[PA158.IG101.SP102]*

Refer to the Project Planning process area for more information about project- and support-group-specific plans for training. *[PA158.IG101.SP102.R101]*

In addition to strategic training needs, organizational training addresses training requirements that are common across projects and support groups. Projects and support groups have the primary responsibility for identifying and addressing their specific training needs. The organization's training staff is only responsible for addressing common cross-project and support-group training needs. In some cases, however, the organization's training staff may address additional training needs of projects and support groups, as negotiated with them, within the context of the training resources available and the organization's training priorities. [PA158.IG101.SP102.N101]

Typical Work Products

1. Common project and support group training needs [PA158.IG101.SP102.W101]
2. Training commitments [PA158.IG101.SP102.W102]

Subpractices

1. Analyze the training needs identified by the various projects and support groups. [PA158.IG101.SP102.SubP101]

   Analysis of project and support group needs is intended to identify common training needs that can be most efficiently addressed organization wide. These needs-analysis activities are used to anticipate future training needs that are first visible at the project and support group level. [PA158.IG101.SP102.SubP101.N101]

2. Negotiate with the various projects and support groups on how their specific training needs will be satisfied. [PA158.IG101.SP102.SubP102]

   The support provided by the organization's training staff depends on the training resources available and the organization's training priorities.
   [PA158.IG101.SP102.SubP102.N101]

   Examples of training appropriately performed by the project or support group include the following: [PA158.IG101.SP102.SubP102.N102]

   - Training in the application domain of the project
   - Training in the unique tools and methods used by the project or support group

3. Document the commitments for providing training support to the projects and support groups. [PA158.IG101.SP102.SubP103]

SP 1.3 Establish an Organizational Training Tactical Plan

Establish and maintain an organizational training tactical plan.
[PA158.IG101.SP103]

The organizational training tactical plan is the plan to deliver the training that is the responsibility of the organization. This plan is adjusted periodically in response to changes (e.g., in needs or resources) and to evaluations of effectiveness. [PA158.IG101.SP103.N101]

Typical Work Products

1. Organizational training tactical plan [PA158.IG101.SP103.W101]

Subpractices

1. Establish plan content. [PA158.IG101.SP103.SubP101]

   Organizational training tactical plans typically contain the following:
   [PA158.IG101.SP103.SubP101.N101]

   - Training needs
   - Training topics
   - Schedules based on training activities and their dependencies
   - Methods used for training

- Requirements and quality standards for training materials
- Training tasks, roles, and responsibilities
- Required resources including tools, facilities, environments, staffing, and skills and knowledge

2. Establish commitments to the plan. [PA158.IG101.SP103.SubP102]

   Documented commitments by those responsible for implementing and supporting the plan are essential for the plan to be effective. [PA158.IG101.SP103.SubP102.N101]

3. Revise plan and commitments as necessary. [PA158.IG101.SP103.SubP103]

SP 1.4 Establish Training Capability

Establish and maintain training capability to address organizational training needs. *[PA158.IG101.SP104]*

Refer to the Decision Analysis and Resolution process area for how to apply decision-making criteria when selecting training approaches and developing training materials. *[PA158.IG101.SP104.R101]*

Typical Work Products

1. Training materials and supporting artifacts [PA158.IG101.SP104.W101]

Subpractices

1. Select the appropriate approaches to satisfy specific organizational training needs. [PA158.IG101.SP104.SubP101]

   Many factors may affect the selection of training approaches, including audience-specific knowledge, costs and schedule, work environment, and so on. Selection of an approach requires consideration of the means to provide skills and knowledge in the most effective way possible given the constraints.

   [PA158.IG101.SP104.SubP101.N101]

   Examples of training approaches include the following: [PA158.IG101.SP104.SubP101.N102]

   - Classroom training
   - Computer-aided instruction
   - Guided self study
   - Formal apprenticeship and mentoring programs
   - Facilitated videos
   - Chalk talks
   - Brown-bag lunch seminars
   - Structured on-the-job training

2. Determine whether to develop training materials internally or acquire them externally. [PA158.IG101.SP104.SubP102]

Determine the costs and benefits of internal training development or of obtaining training externally. [PA158.IG101.SP104.SubP102.N101]

Example criteria that can be used to determine the most effective mode of knowledge or skill acquisition include the following: [PA158.IG101.SP104.SubP102.N102]

- Performance objectives
- Time available to prepare for project execution
- Business objectives
- Availability of in-house expertise
- Availability of training from external sources

Examples of external sources of training include the following: [PA158.IG101.SP104.SubP102.N103]

- Customer-provided training
- Commercially available training courses
- Academic programs
- Professional conferences
- Seminars

3. Develop or obtain training materials. [PA158.IG101.SP104.SubP103]

Training may be provided by the project, by support groups, by the organization, or by an external organization. The organization's training staff coordinates the acquisition and delivery of training regardless of its source. [PA158.IG101.SP104.SubP103.N101]

Examples of training materials include the following: [PA158.IG101.SP104.SubP103.N102]

- Courses
- Computer-aided instruction
- Videos

4. Develop or obtain qualified instructors. [PA158.IG101.SP104.SubP106]

To ensure that internally provided training instructors have the necessary knowledge and training skills, criteria can be defined to identify, develop, and qualify them. In the case of externally provided training, the organization's training staff may investigate how the training provider determines which instructors will deliver the training. This can also be a factor in selecting or continuing to use a specific training provider. [PA158.IG101.SP104.SubP106.N101]

5. Describe the training in the organization's training curriculum.
[PA158.IG101.SP104.SubP104]

Examples of the information provided in the training descriptions for each course include the following: [PA158.IG101.SP104.SubP104.N101]

- Topics covered in the training
- Intended audience
- Prerequisites and preparation for participating
- Training objectives
- Length of the training
- Lesson plans
- Completion criteria for the course
- Criteria for granting training waivers

6. Revise the training materials and supporting artifacts as necessary.
[PA158.IG101.SP104.SubP105]

Examples of situations in which the training materials and supporting artifacts may need to be revised include the following: [PA158.IG101.SP104.SubP105.N101]

- Training needs change (e.g., when new technology associated with the training topic is available)
- An evaluation of the training identifies the need for change (e.g., evaluations of training-effectiveness surveys, training program performance assessments, or instructor evaluation forms)

SG 2 Provide Necessary Training

Training necessary for individuals to perform their roles effectively is provided. *[PA158.IG102]*

In selecting people to be trained, the following should be taken into consideration: [PA158.IG102.N101]

- Background of the target population of training participants
- Prerequisite background to receive training
- Skills and abilities needed by people to perform their roles
- Need for cross-discipline technical-management training for all disciplines, including project management
- Need for managers to have training in appropriate organizational processes

- Need for training in the basic principles of discipline-specific engineering to support personnel in quality management, configuration management, and other related support functions
- Need to provide competency development for critical functional areas

SP 2.1 Deliver Training

Deliver the training following the organizational training tactical plan. *[PA158.IG102.SP101]*

Typical Work Products

1. Delivered training course [PA158.IG102.SP101.W101]

Subpractices

1. Select the people who will receive the training. [PA158.IG102.SP101.SubP101]

   Training is intended to impart knowledge and skills to people performing various roles within the organization. Some people already possess the knowledge and skills required to perform well in their designated roles. Training can be waived for these people, but care should be taken that training waivers are not abused. [PA158.IG102.SP101.SubP101.N101]

2. Schedule the training, including any resources, as necessary (e.g., facilities and instructors). [PA158.IG102.SP101.SubP102]

   Training should be planned and scheduled. Training is provided that has a direct bearing on the expectations of work performance. Therefore, optimal training occurs in a timely manner with regard to imminent job-performance expectations. These expectations often include the following: [PA158.IG102.SP101.SubP102.N101]

   - Training in the use of specialized tools
   - Training in procedures that are new to the individual who will perform them

3. Conduct the training. [PA158.IG102.SP101.SubP103]

   Experienced instructors should perform training. When possible, training is conducted in settings that closely resemble actual performance conditions and includes activities to simulate actual work situations. This approach includes integration of tools, methods, and procedures for competency development. Training is tied to work responsibilities so that on-the-job activities or other outside experiences will reinforce the training within a reasonable time after the training. [PA158.IG102.SP101.SubP103.N101]

4. Track the delivery of training against the plan. [PA158.IG102.SP101.SubP104]

SP 2.2 Establish Training Records

Establish and maintain records of the organizational training.

[PA158.IG102.SP102]

Refer to the Project Monitoring and Control process area for information on how project- or support-group training records are maintained.

[PA158.IG102.SP102.R101]

The scope of this practice is for the training performed at the organizational level. Establishment and maintenance of training records for project- or support-group-sponsored training is the responsibility of each individual project or support group. [PA158.IG102.SP102.N101]

Typical Work Products

1. Training records [PA158.IG102.SP102.W101]
2. Training updates to the organizational repository [PA158.IG102.SP102.W102]

Subpractices

1. Keep records of all students who successfully complete each training course or other approved training activity as well as those who are unsuccessful. [PA158.IG102.SP102.SubP101]
2. Keep records of all staff who have been waived from specific training. [PA158.IG102.SP102.SubP102]

   The rationale for granting a waiver should be documented, and both the manager responsible and the manager of the excepted individual should approve the waiver for organizational training. [PA158.IG102.SP102.SubP102.N101]
3. Keep records of all students who successfully complete their designated required training. [PA158.IG102.SP102.SubP103]
4. Make training records available to the appropriate people for consideration in assignments. [PA158.IG102.SP102.SubP104]

   Training records may be part of a skills matrix developed by the training organization to provide a summary of the experience and education of people, as well as training sponsored by the organization. [PA158.IG102.SP102.SubP104.N101]

SP 2.3 Assess Training Effectiveness

Assess the effectiveness of the organization's training program.

[PA158.IG102.SP103]

A process should exist to determine the effectiveness of training (i.e., how well the training is meeting the organization's needs).

[PA158.IG102.SP103.N101]

Examples of methods used to assess training effectiveness include the following: [PA158.IG102.SP103.N103]

- Testing in the training context
- Post-training surveys of training participants
- Surveys of managers' satisfaction with post-training effects
- Assessment mechanisms embedded in courseware

Measures may be taken to assess the added value of the training against both the project's and organization's objectives. Particular attention should be paid to the need for various training methods, such as training teams as integral work units. When used, performance objectives should be shared with course participants, and should be unambiguous, observable, and verifiable. The results of the training-effectiveness assessment should be used to revise training materials as described in the Establish Training Capability specific practice above. [PA158.IG102.SP103.N102]

Typical Work Products

1. Training-effectiveness surveys [PA158.IG102.SP103.W101]
2. Training program performance assessments [PA158.IG102.SP103.W102]
3. Instructor evaluation forms [PA158.IG102.SP103.W103]
4. Training examinations [PA158.IG102.SP103.W104]

Subpractices

1. Assess in-progress or completed projects to determine whether staff knowledge is adequate for performing project tasks. [PA158.IG102.SP103.SubP101]
2. Provide a mechanism for assessing the effectiveness of each training course with respect to established organizational, project, or individual learning (or performance) objectives. [PA158.IG102.SP103.SubP102]
3. Obtain student evaluations of how well training activities met their needs. [PA158.IG102.SP103.SubP103]

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the organizational training process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for identifying the strategic training needs of the organization, and providing that training. [PA158.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined organizational training process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the organizational training process. *[GP104]*

Elaboration:

This plan for performing the organizational training process differs from the tactical plan for organizational training described in a specific practice in this process area. The plan called for in this generic practice would address the comprehensive planning for all of the specific practices in this process area, from the establishment of strategic training needs all the way through to the assessment of the effectiveness of the organizational training effort. In contrast, the organizational training tactical plan called for in the specific practice would address the periodic planning for the delivery of individual training offerings. [PA158.EL102]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the organizational training process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Examples of people (full or part time, internal or external), and skills needed include the following: [PA158.EL104]

- Subject matter experts
- Curriculum designers
- Instructional designers
- Instructors
- Training administrators

Special facilities may be required for training. When necessary, the facilities required for the activities in the Organizational Training process area are developed or purchased. [PA158.EL118]

Examples of other resources provided include the following tools: [PA158.EL106]

- Instruments for analyzing training needs
- Workstations to be used for training
- Instructional design tools
- Packages for developing presentation materials

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the organizational training process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the organizational training process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA158.EL108]

- Knowledge and skills needs analysis
- Instructional design
- Instructional techniques (e.g., train the trainer)
- Refresher training on subject matter

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the organizational training process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA158.EL109]

- Organizational training tactical plan
- Training records
- Training materials and supporting artifacts
- Instructor evaluation forms

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the organizational training process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include the following: [PA158.EL119]

- Establishing a collaborative environment for discussion of training needs and training effectiveness to ensure that the organization's training needs are met
- Identifying training needs
- Reviewing the organizational training tactical plan
- Assessing training effectiveness

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the organizational training process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA158.EL112]

- Number of training courses delivered (e.g., planned versus actual)
- Post-training evaluation ratings
- Training program quality survey ratings

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the organizational training process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational training process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA158.EL114]

- Identifying training needs and making training available
- Providing necessary training

Examples of work products reviewed include the following: [PA158.EL116]

- Organizational training tactical plan
- Training materials and supporting artifacts
- Instructor evaluation forms

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the organizational training process with higher level management and resolve issues. *[GP112]*

INTEGRATED PROJECT MANAGEMENT FOR IPPD

Project Management

Purpose

The purpose of Integrated Project Management is to establish and manage the project and the involvement of the relevant stakeholders according to an integrated and defined process that is tailored from the organization's set of standard processes. [PA167]

For Integrated Product and Process Development, Integrated Project Management also covers the establishment of a shared vision for the project and a team structure for integrated teams that will carry out the objectives of the project. [PA167.PE101]

Introductory Notes

Integrated Project Management involves the following: [PA167.N102]

- Establishing the project's defined process by tailoring the organization's set of standard processes
- Managing the project using the project's defined process
- Using and contributing to the organizational process assets
- Enabling relevant stakeholders' concerns to be identified, considered, and, when appropriate, addressed during the development of the product
- Ensuring that the relevant stakeholders perform their tasks in a coordinated and timely manner (1) to address product and product-component requirements, plans, objectives, issues, and risks; (2) to fulfill their commitments; and (3) to identify, track, and resolve issues

For Integrated Product and Process Development

Integrated Project Management also involves the following: *[PA167.N102.AMP101]*

- *Establishing a shared vision by and for the project*
- *Establishing a structure of integrated teams that are tasked to accomplish the objectives of the project*

The integrated and defined process that is tailored from the organization's set of standard processes is called the project's defined process. [PA167.N110]

Managing the project's effort, cost, schedule, staffing, risks, and other factors is tied to the tasks of the project's defined process. The implementation and management of the project's defined process are typically described in the project plan. Certain activities may be covered in other plans that affect the project, such as the quality assurance plan, risk management strategy, and the configuration management plan. [PA167.N103]

Since the defined process for each project is tailored from the organization's set of standard processes, variability among projects is typically reduced and projects can more easily share process assets, data, and lessons learned. [PA167.N104]

This process area also addresses the coordination of all activities associated with the project including the following: [PA167.N105]

- Technical activities such as requirements development, design, and verification
- Support activities such as configuration management, documentation, marketing, and training

The working interfaces and interactions among relevant stakeholders internal and external to the project are planned and managed to ensure the quality and integrity of the entire product. Relevant stakeholders participate, as appropriate, in defining the project's defined process and the project plan. Reviews and exchanges are regularly conducted with the relevant stakeholders and coordination issues receive appropriate attention. Reviews and exchanges are regularly conducted with the relevant stakeholders to ensure that coordination issues receive appropriate attention and everyone involved with the project is appropriately aware of the status, plans, and activities. In defining the project's defined process, formal interfaces are created as necessary to ensure that appropriate coordination and collaboration occurs. [PA167.N107]

See Chapter 3 for an explanation of how "relevant stakeholder" is used in the CMMI Product Suite. [PA167.N106]

This process area applies in any organizational structure, including projects that are structured as line organizations, matrix organizations, or integrated teams. The terminology should be appropriately interpreted for the organizational structure in place. [PA167.N108]

Related Process Areas

Refer to the Project Planning process area for more information about planning the project. [PA167.R101]

Refer to the Project Monitoring and Control process area for more information about monitoring and controlling the project. [PA167.R102]

Refer to the Project Planning process area for more information about identifying relevant stakeholders and their appropriate involvement in the project. [PA167.R103]

Refer to the Verification process area for more information about peer reviews. [PA167.R104]

Refer to the Organizational Process Definition process area for more information about organizational process assets. [PA167.R105]

Refer to the Measurement and Analysis process area for more information about defining a process for measuring and analyzing processes. [PA167.R106]

Refer to the Integrated Teaming process area for more information about how teams are established and maintained. [PA167.R107]

Refer to the Organizational Environment for Integration process area for more information about the work environment, the creation of the organization's shared vision, and managing people for integration. [PA167.R108]

Specific and Generic Goals

SG 1 **Use the Project's Defined Process** [PA167.IG101]

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

SG 2 **Coordinate and Collaborate with Relevant Stakeholders** [PA167.IG102]

Coordination and collaboration of the project with relevant stakeholders is conducted.

SG 3 **Use the Project's Shared Vision for IPPD** [PA167.IG103]

The project is conducted using the project's shared vision.

SG 4 **Organize Integrated Teams for IPPD** [PA167.IG104]

The integrated teams needed to execute the project are identified, defined, structured, and tasked.

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Use the Project's Defined Process [PA167.IG101]

SP 1.1	Establish the Project's Defined Process
SP 1.2	Use Organizational Process Assets for Planning Project Activities
SP 1.3	Integrate Plans
SP 1.4	Manage the Project Using the Integrated Plans
SP 1.5	Contribute to the Organizational Process Assets

SG 2 Coordinate and Collaborate with Relevant Stakeholders [PA167.IG102]

SP 2.1	Manage Stakeholder Involvement
SP 2.2	Manage Dependencies
SP 2.3	Resolve Coordination Issues

SG 3 Use the Project's Shared Vision for IPPD [PA167.IG103]

SP 3.1	Define Project's Shared-Vision Context
SP 3.2	Establish the Project's Shared Vision

SG 4 Organize Integrated Teams for IPPD [PA167.IG104]

SP 4.1	Determine Integrated Team Structure for the Project
SP 4.2	Develop a Preliminary Distribution of Requirements to Integrated Teams
SP 4.3	Establish Integrated Teams

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 3.1	(AB 1)	Establish a Defined Process
GP 2.2	(AB 2)	Plan the Process
GP 2.3	(AB 3)	Provide Resources
GP 2.4	(AB 4)	Assign Responsibility
GP 2.5	(AB 5)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 3.2	(DI 4)	Collect Improvement Information
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

Specific Practices by Goal

SG 1 Use the Project's Defined Process

The project is conducted using a defined process that is tailored from the organization's set of standard processes. *[PA167.IG101]*

The project's defined process must include those processes from the organization's set of standard processes that address all processes necessary to develop and maintain the product. The product-related life-cycle processes, such as the manufacturing and support processes, are developed concurrently with the product. [PA167.IG101.N101]

SP 1.1 Establish the Project's Defined Process

Establish and maintain the project's defined process. *[PA167.IG101.SP101]*

Refer to the Organizational Process Definition process area for more information about the organizational process assets. *[PA167.IG101.SP101.R101]*

Refer to the Organizational Process Focus process area for more information about organizational process needs and objectives.
[PA167.IG101.SP101.R102]

The project's defined process consists of defined processes that form an integrated, coherent life cycle for the project. [PA167.IG101.SP101.N101]

The project's defined process covers all the processes needed by the project, including those processes addressed by the process areas at maturity level 2. [PA167.IG101.SP101.N103]

> *For Integrated Product and Process Development*
> *The project's defined process includes all life-cycle processes including the IPPD processes that will be applied by the project (tailored from the organization's IPPD processes). Processes to select the team structure, allocate limited personnel resources, implement cross-integrated team communication, and conduct issue-resolution processes are part of the project's defined process.* *[PA167.IG101.SP101.N103.AMP101]*

The project's defined process should satisfy the project's contractual and operational needs, opportunities, and constraints. It is designed to provide a best fit for the project's needs. A project's defined process is based on the following: [PA167.IG101.SP101.N102]

- Customer requirements
- Product and product-component requirements
- Commitments
- Organizational process needs and objectives
- Operational environment
- Business environment

Typical Work Products

1. The project's defined process [PA167.IG101.SP101.W101]

Subpractices

1. Select a life-cycle model from those available from the organizational process assets. [PA167.IG101.SP101.SubP101]
2. Select the standard processes from the organization's set of standard processes that best fit the needs of the project.
   [PA167.IG101.SP101.SubP102]

3. Tailor the organization's set of standard processes and other organizational process assets according to the tailoring guidelines to produce the project's defined process. [PA167.IG101.SP101.SubP103]

   Sometimes the available life-cycle models and standard processes are inadequate to meet a specific project's needs. Sometimes the project will be unable to produce required work products or measures. In such circumstances, the project will need to seek approval to deviate from what is required by the organization. Waivers are provided for this purpose. [PA167.IG101.SP101.SubP103.N101]

4. Use other artifacts from the organization's process asset library as appropriate. [PA167.IG101.SP101.SubP104]

   Other artifacts may include the following: [PA167.IG101.SP101.SubP104.N101]

   - Lessons-learned documents
   - Templates
   - Example documents
   - Estimating models

5. Document the project's defined process. [PA167.IG101.SP101.SubP105]

   The project's defined process covers all the engineering, management, and support activities for the project and its interfaces to relevant stakeholders. [PA167.IG101.SP101.SubP105.N101]

   Examples of project activities include the following: [PA167.IG101.SP101.SubP105.N102]

   - Project planning
   - Project monitoring and controlling
   - Requirements development
   - Requirements management
   - Design and implementation
   - Verification and validation
   - Product integration
   - Acquisition management
   - Configuration management
   - Quality assurance

6. Conduct peer reviews of the project's defined process. [PA167.IG101.SP101.SubP106]

   Refer to the Verification process area for more information about conducting peer reviews. *[PA167.IG101.SP101.SubP106.R101]*

7. Revise the project's defined process as necessary. [PA167.IG101.SP101.SubP107]

SP 1.2 Use Organizational Process Assets for Planning Project Activities

Use the organizational process assets and measurement repository for estimating and planning the project's activities.

[PA167.IG101.SP102]

Refer to the Organizational Process Definition process area for more information about organizational process assets and the organization's measurement repository. *[PA167.IG101.SP102.R101]*

Typical Work Products

1. Project estimates [PA167.IG101.SP102.W101]
2. Project plans [PA167.IG101.SP102.W102]

Subpractices

1. Base the activities for estimating and planning on the tasks and work products of the project's defined process. [PA167.IG101.SP102.SubP101]

   An understanding of the relationships among the various tasks and work products of the project's defined process, and of the roles to be performed by the relevant stakeholders, is a basis for developing a realistic plan. [PA167.IG101.SP102.SubP101.N101]

2. Use the organization's measurement repository in estimating the project's planning parameters. [PA167.IG101.SP102.SubP102]

   This estimate typically includes the following: [PA167.IG101.SP102.SubP102.N101]

   - Using appropriate historical data from this project or similar projects
   - Accounting for and recording similarities and differences between the current project and those projects whose historical data will be used
   - Independently validating the historical data
   - Recording the reasoning, assumptions, and rationale used to select the historical data

   Examples of parameters that are considered for similarities and differences include the following: [PA167.IG101.SP102.SubP102.N102]

   - Work product and task attributes
   - Application domain
   - Design approach
   - Operational environment
   - Experience of the people

Examples of data contained in the organization's measurement repository include the following: [PA167.IG101.SP102.SubP102.N103]

- Size of work products or other work product attributes
- Effort
- Cost
- Schedule
- Staffing
- Defects

SP 1.3 Integrate Plans

Integrate the project plan and the other plans that affect the project to describe the project's defined process. *[PA167.IG101.SP103]*

Refer to the Project Planning process area for more information about establishing and maintaining a project plan. *[PA167.IG101.SP103.R101]*

Refer to the Organizational Process Definition process area for more information about organizational process assets and, in particular, the organization's measurement repository. *[PA167.IG101.SP103.R102]*

Refer to the Measurement and Analysis process area for more information about defining measures and measurement activities and using analytic techniques. *[PA167.IG101.SP103.R103]*

Refer to the Risk Management process area for more information about identifying and analyzing risks. *[PA167.IG101.SP103.R104]*

Refer to the Organizational Process Focus process area for more information about organizational process needs and objectives. *[PA167.IG101.SP103.R105]*

This specific practice extends the specific practices for establishing and maintaining a project plan to address additional planning activities such as incorporating the project's defined process, coordinating with relevant stakeholders, using organizational process assets, incorporating plans for peer reviews, and establishing objective entry and exit criteria for tasks. [PA167.IG101.SP103.N101]

The development of the project plan should account for current and projected needs, objectives, and requirements of the organization, customer, and end users, as appropriate. [PA167.IG101.SP103.N102]

For Integrated Product and Process Development

The plans of the integrated teams are included in this integration. Developing a complete project plan and the project's defined process may require an iterative effort if a complex, multi-layered, integrated team structure is being deployed. [PA167.IG101.SP103.N102.AMP101]

Typical Work Products

1. Integrated plans [PA167.IG101.SP103.W101]

Subpractices

1. Integrate other plans that affect the project with the project plan.

   [PA167.IG101.SP103.SubP101]

   Other plans that affect the project may include the following:

   [PA167.IG101.SP103.SubP101.N101]

   - Quality assurance plans
   - Configuration management plans
   - Risk management strategy
   - Documentation plans

2. Incorporate into the project plan the definitions of measures and measurement activities for managing the project.

   [PA167.IG101.SP103.SubP102]

   Examples of measures that would be incorporated include the following:

   [PA167.IG101.SP103.SubP102.N101]

   - Organization's common set of measures
   - Additional project-specific measures

3. Identify and analyze product and project interface risks.

   [PA167.IG101.SP103.SubP103]

   Examples of product and project interface risks include the following:

   [PA167.IG101.SP103.SubP103.N101]

   - Incomplete interface descriptions
   - Unavailability of tools or test equipment
   - Availability of COTS components
   - Inadequate or ineffective team interfaces

4. Schedule the tasks in a sequence that accounts for critical development factors and project risks. [PA167.IG101.SP103.SubP104]

Examples of factors considered in scheduling include the following: [PA167.IG101.SP103.SubP104.N101]

- Size and complexity of the tasks
- Integration and test issues
- Needs of the customer and end users
- Availability of critical resources
- Availability of key personnel

5. Incorporate the plans for performing peer reviews on the work products of the project's defined process. [PA167.IG101.SP103.SubP105]

   Refer to the Verification process area for more information about peer reviews. *[PA167.IG101.SP103.SubP105.R101]*

6. Incorporate the training needed to perform the project's defined process in the project's training plans. [PA167.IG101.SP103.SubP106]

   This task typically involves negotiating with the organizational training group the support they will provide. [PA167.IG101.SP103.SubP106.N101]

7. Establish objective entry and exit criteria to authorize the initiation and completion of the tasks described in the work breakdown structure (WBS). [PA167.IG101.SP103.SubP107]

   Refer to the Project Planning process area for more information about the WBS. *[PA167.IG101.SP103.SubP107.R101]*

8. Ensure that the project plan is appropriately compatible with the plans of relevant stakeholders. [PA167.IG101.SP103.SubP108]

   Typically the plan and changes to the plan will be reviewed for compatibility. [PA167.IG101.SP103.SubP108.N101]

9. Identify how conflicts will be resolved that arise among relevant stakeholders. [PA167.IG101.SP103.SubP109]

SP 1.4 Manage the Project Using the Integrated Plans

Manage the project using the project plan, the other plans that affect the project, and the project's defined process. *[PA167.IG101.SP104]*

Refer to the Organizational Process Definition process area for more information about the organizational process assets. *[PA167.IG101.SP104.R101]*

Refer to the Organizational Process Focus process area for more information about organizational process needs and objectives and coordinating process-improvement activities with the rest of the organization. *[PA167.IG101.SP104.R102]*

Refer to the Risk Management process area for more information about managing risks. [PA167.IG101.SP104.R103]

Refer to the Project Monitoring and Control process area for more information about monitoring and controlling the project.
[PA167.IG101.SP104.R104]

Typical Work Products

1. Work products created by performing the project's defined process [PA167.IG101.SP104.W101]
2. Collected measures ("actuals") and progress records or reports [PA167.IG101.SP104.W102]
3. Revised requirements, plans, and commitments [PA167.IG101.SP104.W103]
4. Integrated plans [PA167.IG101.SP104.W104]

Subpractices

1. Implement the project's defined process using the organization's process asset library. [PA167.IG101.SP104.SubP101]

   This task typically includes the following: [PA167.IG101.SP104.SubP101.N101]

   - Incorporating artifacts from the organization's process asset library into the project as appropriate
   - Using lessons learned from the organization's process asset library to manage the project

2. Monitor and control the project's activities and work products using the project's defined process, project plan, and other plans that affect the project. [PA167.IG101.SP104.SubP102]

   This task typically includes the following: [PA167.IG101.SP104.SubP102.N101]

   - Using the defined entry and exit criteria to authorize the initiation and determine the completion of the tasks
   - Monitoring the activities that could significantly affect the actual values of the project's planning parameters
   - Tracking the project's planning parameters using measurable thresholds that will trigger investigation and appropriate actions
   - Monitoring product and project interface risks
   - Managing external and internal commitments based on the plans for the tasks and work products of implementing the project's defined process

   An understanding of the relationships among the various tasks and work products of the project's defined process, and of the roles to be performed by the relevant stakeholders, along with well-defined control mechanisms (e.g., peer reviews), achieves better visibility into the project's performance and better control of the project. [PA167.IG101.SP104.SubP102.N102]

3. Obtain and analyze the selected measures to manage the project and support the organization's needs. [PA167.IG101.SP104.SubP103]

   Refer to the Measurement and Analysis process area for more information about defining a process for obtaining and analyzing measures. *[PA167.IG101.SP104.SubP103.R101]*

4. Periodically review the adequacy of the environment to meet the project's needs and to support coordination. [PA167.IG101.SP104.SubP104]

   Examples of actions that might be taken include the following:
   [PA167.IG101.SP104.SubP104.N101]

   - Adding new tools
   - Acquiring additional networks, equipment, training, and support

5. Periodically review and align the project's performance with the current and anticipated needs, objectives, and requirements of the organization, customer, and end users, as appropriate.
   [PA167.IG101.SP104.SubP105]

   This review includes alignment with the organizational process needs and objectives. [PA167.IG101.SP104.SubP105.N101]

   Examples of actions that achieve alignment include the following:
   [PA167.IG101.SP104.SubP105.N102]

   - Accelerating the schedule, with appropriate adjustments to other planning parameters and the project risks
   - Changing the requirements in response to a change in market opportunities or customer and end-user needs
   - Terminating the project

SP 1.5 Contribute to the Organizational Process Assets

Contribute work products, measures, and documented experiences to the organizational process assets. *[PA167.IG101.SP105]*

Refer to the Organizational Process Focus process area for more information about process-improvement proposals. *[PA167.IG101.SP105.R101]*

Refer to the Organizational Process Definition process area for more information about the organizational process assets, the organization's measurement repository, and the organization's process asset library.
[PA167.IG101.SP105.R102]

This specific practice addresses collecting information from processes in the project's defined process. [PA167.IG101.SP105.N101]

Typical Work Products

1. Proposed improvements to the organizational process assets [PA167.IG101.SP105.W101]
2. Actual process and product measures collected from the project [PA167.IG101.SP105.W102]
3. Documentation (e.g., exemplary process descriptions, plans, training modules, checklists, and lessons learned) [PA167.IG101.SP105.W103]

Subpractices

1. Propose improvements to the organizational process assets. [PA167.IG101.SP105.SubP101]
2. Store process and product measures in the organization's measurement repository. [PA167.IG101.SP105.SubP102]

   Refer to the Project Planning process area for more information about recording planning and re-planning data. *[PA167.IG101.SP105.SubP102.R101]*

   Refer to the Project Monitoring and Control process area for more information about recording measures. *[PA167.IG101.SP105.SubP102.R102]*

   This typically includes the following: [PA167.IG101.SP105.SubP102.N101]

   - Planning data
   - Re-planning data
   - Measures

   Examples of data recorded by the project include the following: [PA167.IG101.SP105.SubP102.N102]

   - Task descriptions
   - Assumptions
   - Estimates
   - Revised estimates
   - Definitions of recorded data and measures
   - Measures
   - Context information that relates the measures to the activities performed and work products produced
   - Associated information needed to reconstruct the estimates, assess their reasonableness, and derive estimates for new work

3. Submit documentation for possible inclusion in the organization's process asset library. [PA167.IG101.SP105.SubP103]

Examples of documentation include the following: [PA167.IG101.SP105.SubP103.N101]

- Exemplary process descriptions
- Training modules
- Exemplary plans
- Checklists

4. Document lessons learned from the project for inclusion in the organization's process asset library. [PA167.IG101.SP105.SubP104]

SG 2 Coordinate and Collaborate with Relevant Stakeholders

Coordination and collaboration of the project with relevant stakeholders is conducted. *[PA167.IG102]*

SP 2.1 Manage Stakeholder Involvement

Manage the involvement of the relevant stakeholders in the project. *[PA167.IG102.SP101]*

Refer to the Project Planning process area for more information about identifying stakeholders and their appropriate involvement and on establishing and maintaining commitments. *[PA167.IG102.SP101.R101]*

Typical Work Products

1. Agendas and schedules for collaborative activities [PA167.IG102.SP101.W101]
2. Documented issues (e.g., issues with customer requirements, product and product-component requirements, product architecture, and product design) [PA167.IG102.SP101.W102]
3. Recommendations for resolving relevant stakeholder issues [PA167.IG102.SP101.W103]

Subpractices

1. Coordinate with the relevant stakeholders who should participate in the project's activities. [PA167.IG102.SP101.SubP101]

   The relevant stakeholders should already be identified in the project plan. [PA167.IG102.SP101.SubP101.N101]

2. Ensure that work products that are produced to satisfy commitments meet the requirements of the recipient projects. [PA167.IG102.SP101.SubP103]

   Refer to the Verification process area for more information about determining acceptability of work products. *[PA167.IG102.SP101.SubP103.R101]*

This task typically includes the following: [PA167.IG102.SP101.SubP103.N101]

- Reviewing, demonstrating, or testing, as appropriate, each work product produced by relevant stakeholders
- Reviewing, demonstrating, or testing, as appropriate, each work product produced by the project for other projects with representatives of the projects receiving the work product
- Resolving issues related to the acceptance of the work products

3. Develop recommendations and coordinate the actions to resolve misunderstandings and problems with the product and product-component requirements, product and product-component architecture, and product and product-component design.
[PA167.IG102.SP101.SubP104]

SP 2.2 Manage Dependencies

Participate with relevant stakeholders to identify, negotiate, and track critical dependencies. *[PA167.IG102.SP102]*

Refer to the Project Planning process area for more information about identifying stakeholders and their appropriate involvement and about establishing and maintaining commitments. *[PA167.IG102.SP102.R101]*

Typical Work Products

1. Defects, issues, and action items resulting from reviews with relevant stakeholders [PA167.IG102.SP102.W102]
2. Critical dependencies [PA167.IG102.SP102.W103]
3. Commitments to address critical dependencies [PA167.IG102.SP102.W104]
4. Status of critical dependencies [PA167.IG102.SP102.W105]

Subpractices

1. Conduct reviews with relevant stakeholders. [PA167.IG102.SP102.SubP101]
2. Identify each critical dependency. [PA167.IG102.SP102.SubP102]
3. Establish need dates and plan dates for each critical dependency based on the project schedule. [PA167.IG102.SP102.SubP103]
4. Review and get agreement on the commitments to address each critical dependency with the people responsible for providing the work product and the people receiving the work product.
[PA167.IG102.SP102.SubP104]
5. Document the critical dependencies and commitments.
[PA167.IG102.SP102.SubP105]

Documentation of commitments typically includes the following:
[PA167.IG102.SP102.SubP105.N101]

- Describing the commitment
- Identifying who made the commitment
- Identifying who is responsible for satisfying the commitment
- Specifying when the commitment will be satisfied
- Specifying the criteria for determining if the commitment has been satisfied

6. Track the critical dependencies and commitments and take corrective action as appropriate. [PA167.IG102.SP102.SubP106]

Refer to the Project Monitoring and Control process area for more information about tracking commitments. *[PA167.IG102.SP102.SubP106.R101]*

Tracking the critical dependencies typically includes the following:
[PA167.IG102.SP102.SubP106.N101]

- Evaluating the effects of late and early completion for impacts on future activities and milestones
- Resolving actual and potential problems with the responsible people where possible
- Escalating to the appropriate managers the actual and potential problems not resolvable with the responsible people

SP 2.3 Resolve Coordination Issues

Resolve issues with relevant stakeholders. *[PA167.IG102.SP103]*

Examples of coordination issues include the following: [PA167.IG102.SP103.N101]

- Late critical dependencies and commitments
- Product and product-component requirements and design defects
- Product-level problems
- Unavailability of critical resources or personnel

Typical Work Products

1. Relevant stakeholder coordination issues [PA167.IG102.SP103.W101]
2. Status of relevant stakeholder coordination issues [PA167.IG102.SP103.W102]

Subpractices

1. Identify and document issues. [PA167.IG102.SP103.SubP101]
2. Communicate issues to the relevant stakeholders.
[PA167.IG102.SP103.SubP102]

3. Resolve issues with the relevant stakeholders. [PA167.IG102.SP103.SubP103]
4. Escalate to the appropriate managers those issues not resolvable with the relevant stakeholders. [PA167.IG102.SP103.SubP104]
5. Track the issues to closure. [PA167.IG102.SP103.SubP105]
6. Communicate with the relevant stakeholders on the status and resolution of the issues. [PA167.IG102.SP103.SubP106]

The following two specific goals, Use the Project's Shared Vision for IPPD, and Organize Integrated Teams for IPPD, are only required for IPPD.

SG 3 Use the Project's Shared Vision for IPPD

The project is conducted using the project's shared vision. *[PA167.IG103]*

The purpose of creating a shared vision is to achieve a unity of purpose. Creating a shared vision requires that all people in the project have an opportunity to speak and be heard about what really matters to them. The project's shared vision captures the project's guiding principles, including mission, objectives, expected behavior, and values. The project's guiding principles should be consistent with those of the organization. The implementation of the project's shared vision in work can become part of the project's process for doing that work. As a result, it is subject to the same requirements for measurement, review, and corrective action as other processes. [PA167.IG103.N101]

The value of a shared vision is that people understand and can adopt its principles to guide their actions and decisions. Shared visions tend to focus on an end state while leaving room for personal and team innovation, creativity, and enthusiasm. The activities of the individuals, teams, and project are aligned with the shared vision (i.e., the activities contribute to the achievement of the objectives expressed in the shared vision). [PA167.IG103.N102]

SP 3.1 Define Project's Shared-Vision Context

Identify expectations, constraints, interfaces, and operational conditions applicable to the project's shared vision. *[PA167.IG103.SP101]*

Refer to the Organizational Environment for Integration process area for more information about the organization's shared vision.

[PA167.IG103.SP101.R101]

A project does not operate in isolation. Understanding organizational expectations and constraints allows for alignment of the project's direction, activities, and shared vision with the organization's and helps create a common purpose within which project activities can be coordinated. To enable this, it is critical to understand (1) the interfaces between the project and stakeholders external to the project; (2) the objectives and expectations of all relevant stakeholders (internal and external); and (3) conditions within which the project must operate. Gaining awareness in these three areas ensures that the project's direction and activities are consistent with the broader objectives of the organization. [PA167.IG103.SP101.N101]

The project's shared-vision context has both an external and internal aspect. The external aspect has to do with the overlying vision and objectives as well as interfaces outside of the project. The internal aspect is about aligning project members' personal aspirations and objectives with the project's vision and purpose. [PA167.IG103.SP101.N102]

Typical Work Products

1. Organizational expectations and constraints that apply to the project [PA167.IG103.SP101.W101]
2. Summary of project members' personal aspirations for the project [PA167.IG103.SP101.W102]
3. External interfaces that the project is required to observe [PA167.IG103.SP101.W103]
4. Operational conditions that affect the project's activities [PA167.IG103.SP101.W104]
5. Project's shared-vision context [PA167.IG103.SP101.W105]

Subpractices

1. Identify expectations, constraints, interfaces, and operational conditions about the organization and project that affect the project's shared vision. [PA167.IG103.SP101.SubP101]
2. Elicit project members' perspectives and aspirations for the project. [PA167.IG103.SP101.SubP102]
3. Create a description of the project's shared-vision context. [PA167.IG103.SP101.SubP103]

SP 3.2 Establish the Project's Shared Vision

Establish and maintain a shared vision for the project. *[PA167.IG103.SP102]*

A shared vision is created by the project and for the project, in alignment with the organization's shared vision. [PA167.IG103.SP102.N101]

Refer to the Organizational Environment for Integration process area for more information about the organization's shared vision.

[PA167.IG103.SP102.N101.R101]

When creating a shared vision, consider: [PA167.IG103.SP102.N102]

- external stakeholder expectations and requirements
- the aspirations and expectations of the leader and project members
- the project's objectives
- the conditions and outcomes the project will create
- interfaces the project needs to maintain
- the visions created by the organization and interfacing groups
- the constraints imposed by outside authorities (e.g., environmental regulations)
- project operation while working to achieve its objectives (both principles and behaviors)

When creating a shared vision, all people in the project should be invited to participate. Although there may be a draft proposal, the larger population must have an opportunity to speak and be heard about what really matters to them. The shared vision is articulated in terms of both the core ideology (values, principles, and behaviors) and the desired future to which each member of the project can commit.

[PA167.IG103.SP102.N103]

An effective communications strategy is key to implementing and focusing the shared vision throughout the project. Promulgation of the shared vision is a public declaration of the commitment of the project to their shared vision and provides the opportunity for others to examine, understand, and align their activities in a common direction. The shared vision should be communicated, and agreement and commitment of the relevant stakeholders should be obtained. [PA167.IG103.SP102.N104]

Effective communications are also especially important when incorporating new project members. New members of the project often need more or special attention to ensure that they understand the shared vision, have a stake in it, and are prepared to follow it in doing their work. [PA167.IG103.SP102.N105]

Typical Work Products

1. Meeting minutes for team-building exercises [PA167.IG103.SP102.W101]
2. Shared vision and objective statements [PA167.IG103.SP102.W102]
3. Statement of values and principles [PA167.IG103.SP102.W103]
4. Communications strategy [PA167.IG103.SP102.W105]

5. Handbook for new members of the project [PA167.IG103.SP102.W106]
6. Presentations to relevant stakeholders [PA167.IG103.SP102.W107]
7. Published principles, shared-vision statement, mission statement, and objectives (e.g., posters, wallet cards published on posters suitable for wall hanging) [PA167.IG103.SP102.W109]

Subpractices

1. Hold meetings or workshops to create the project's shared vision. [PA167.IG103.SP102.SubP101]
2. Articulate the project's shared vision in terms of purpose or mission, vision, values, and objectives. [PA167.IG103.SP102.SubP102]
3. Reach consensus on the project's shared vision. [PA167.IG103.SP102.SubP103]
4. Establish a strategy to communicate the project's shared vision both externally and internally. [PA167.IG103.SP102.SubP104]
5. Make presentations suitable for the various audiences that need to be informed about the project's shared vision. [PA167.IG103.SP102.SubP105]
6. Check that project and individual activities and tasks are aligned with the project's shared vision. [PA167.IG103.SP102.SubP106]

SG 4 Organize Integrated Teams for IPPD

The integrated teams needed to execute the project are identified, defined, structured, and tasked. *[PA167.IG104]*

The purpose of this specific goal and its specific practices is to create an integrated team structure that will efficiently meet the project's requirements and produce a quality product. The integrated team structure partitions responsibilities, requirements, and resources to teams so that the right expertise and abilities are available to produce the assigned products. The integrated teams are organized to facilitate communications between teams and to honor interfaces between product components. [PA167.IG104.N101]

Organizing integrated teams to realize IPPD requires care and deliberation. As the project evolves, integrated team structures are reevaluated for continued applicability. For example, once the product-component requirements are established, it may be appropriate to replace a leader having expertise in design with one having more expertise in manufacturing or in verification. [PA167.IG104.N102]

The teams in the structure must be appropriately integrated with each other. The interface between two integrated teams should be specified when one team has responsibility for a work product that has an interface requirement referring to a work product of the other team. An interface between teams should be specified when one team produces a work product that will be used by another. An interface should exist when two teams share responsibility for a general requirement of the product. Each of these types of interfaces between integrated teams may require a different type of collaboration as appropriate. [PA167.IG104.N103]

SP 4.1 Determine Integrated Team Structure for the Project

Determine the integrated team structure that will best meet the project objectives and constraints. *[PA167.IG104.SP101]*

Product requirements, cost, schedule, risk, resource projections, business processes, the project's defined process, and organizational guidelines are evaluated to establish the basis for defining integrated teams and their responsibilities, authorities, and interrelationships. [PA167.IG104.SP101.N101]

The simplest integrated team structure from an IPPD perspective evolves when the WBS is a work-product-oriented hierarchy, and resources are available to staff a team with the expertise needed to adequately address the entire life of the product for each work product in that hierarchy. More complex structuring occurs when the WBS is not product oriented, product risks are not uniform, and resources are constrained. [PA167.IG104.SP101.N102]

Structuring integrated teams is dependent on: [PA167.IG104.SP101.N103]

- Product risk and complexity
- Location and types of risks
- Integration risks, including product-component interfaces and inter-team communication
- Resources, including availability of appropriately skilled people
- Limitations on team size for effective collaboration
- Need for team membership of stakeholders external to the project
- Business processes
- Organizational structure

The integrated team structure can include the whole project as an integrated team. In this case the project team would need to satisfy the requirements of the Integrated Teaming process area (e.g., it would need a shared vision [created in the Use the Project's Shared Vision for IPPD specific goal of this process area], a charter, clearly defined responsibilities, operating principles, and collaborative interfaces with other teams outside of the project). [PA167.IG104.SP101.N104]

If a project team has too many members for effective collaboration, the project team should be divided into subteams of appropriate size. [PA167.IG104.SP101.N105]

Typical Work Products

1. Assessments of the product and product architectures, including risk and complexity [PA167.IG104.SP101.W101]
2. Integrated team structures based on the WBS and adaptations [PA167.IG104.SP101.W102]
3. Alternative concepts for integrated team structures that include responsibilities, scope, and interfaces [PA167.IG104.SP101.W103]
4. Selected integrated team structure [PA167.IG104.SP101.W104]

Subpractices

1. Determine the risks in the products and product suite. [PA167.IG104.SP101.SubP101]

   Refer to the Risk Management process area for more information about practices associated with risk determination. *[PA167.IG104.SP101.SubP101.R101]*

2. Determine likely resource requirements and availability. [PA167.IG104.SP101.SubP102]

   Refer to the Project Planning process area for more information about resource assignments. *[PA167.IG104.SP101.SubP102.R101]*

   Constraints on the available assets impact which teams are formed and how the teams are structured. [PA167.IG104.SP101.SubP102.N101]

3. Establish work-product-based responsibilities. [PA167.IG104.SP101.SubP103]

   Each team in the team structure should be responsible for specific tasks and work products. The team structure should tie to the WBS used by the project. [PA167.IG104.SP101.SubP103.N101]

4. Consider organizational process assets for opportunities, constraints, and other factors that might influence integrated team structure. [PA167.IG104.SP101.SubP104]

Organizational process assets can provide guidance to assist the project in structuring and implementing integrated teams. Such assets may include: [PA167.IG104.SP101.SubP104.N101]

- Team formation and structures
- Team authority guidelines
- Implementation techniques for IPPD
- Guidelines for managing risks in IPPD
- Guidelines for establishing lines of communication and authority
- Team leader selection criteria
- Team responsibility guidelines

5. Develop an understanding of the organization's shared vision, the project's shared vision, and the organization's standard processes and organizational process assets applicable to teams and team structures. [PA167.IG104.SP101.SubP105]

   The shared visions for the organization and project are examined. These visions help the planners focus on attributes critical to the organization and the project. Organizational processes provide information to streamline the planning process. These may be particularly useful when establishing reporting mechanisms for integrated teams and when integrated team structures are constructed in hybrid situations such as project teams consisting of both functional and product teams. [PA167.IG104.SP101.SubP105.N101]

6. Identify alternative integrated team structures. [PA167.IG104.SP101.SubP106]

   Alternative integrated team structures are frequently developed for collaborative evaluation prior to selection of the structure to be employed. Much like any other set of design alternatives, extreme cases should be included to test the adequacy of the solution set. Innovative concepts in integrated team structure that promote integration as well as efficiency can be overlooked if planning is limited to devising a single team structure. [PA167.IG104.SP101.SubP106.N101]

7. Evaluate alternatives and select an integrated team structure. [PA167.IG104.SP101.SubP107]

   Refer to the Decision Analysis and Resolution process area for more information about a formal evaluation process for selecting the team structure. *[PA167.IG104.SP101.SubP107.R101]*

   The integrated team structure that meets the objectives, subject to the constraints of time, money, and people, is collaboratively evaluated and selected from the alternative integrated team structures. From the perspective of team-structure maintenance, this activity would include assessments of the teams already deployed and candidate alternative structures. [PA167.IG104.SP101.SubP107.N101]

SP 4.2 Develop a Preliminary Distribution of Requirements to Integrated Teams

Develop a preliminary distribution of requirements, responsibilities, authorities, tasks, and interfaces to teams in the selected integrated team structure. *[PA167.IG104.SP102]*

This preliminary distribution of requirements to integrated teams is done before any teams are formed to verify that the selected team structure is workable and covers all the necessary requirements, responsibilities, authorities, tasks, and interfaces. If this check is not satisfied it is necessary to repeat the selection of team structure to meet this check. This preliminary distribution is a useful compendium of information that the integrated teams must know to effectively carry out their tasks in an integrated way. [PA167.IG104.SP102.N101]

Typical Work Products

1. Preliminary distribution of integrated team authorities and responsibilities [PA167.IG104.SP102.W101]
2. Preliminary distribution of the work product requirements, technical interfaces, and business (e.g., cost accounting, project management) interfaces each integrated team will be responsible for satisfying [PA167.IG104.SP102.W102]

Subpractices

1. Assemble requirements and interfaces for integrated teams.
   [PA167.IG104.SP102.SubP101]

   Assemble the tasks and work products, and the associated requirements and interfaces. Assign these to the appropriate integrated teams.
   [PA167.IG104.SP102.SubP101.N101]

2. Check that the preliminary distribution of requirements and interfaces covers all specified product requirements and other requirements. [PA167.IG104.SP102.SubP102]

   In the event that complete coverage of requirements is not achieved, corrective action should be taken to redistribute requirements or alter the integrated team structure. [PA167.IG104.SP102.SubP102.N101]

3. Define responsibilities and authorities for integrated teams.
   [PA167.IG104.SP102.SubP103]

   Business, management, and other nontechnical responsibilities and authorities for the integrated team are necessary elements to proper team function. Integrated team responsibilities and authorities are normally developed by the project and are consistent with established organization practices. Such factors include:
   [PA167.IG104.SP102.SubP103.N101]

   - Authority of teams to pick their own leader

- Authority of teams to implement subteams (e.g., a product team forming an integration subteam)
- Reporting chains
- Reporting requirements (cost, schedule, and performance status)
- Progress reporting measures and methods

4. Designate the sponsor for each integrated team.
[PA167.IG104.SP102.SubP104]

An integrated team sponsor is a manager (individual or team) who is responsible for establishing an integrated team, monitoring its activities and progress, and taking corrective action when needed. A manager may sponsor one or many teams. [PA167.IG104.SP102.SubP104.N101]

SP 4.3 Establish Integrated Teams

Establish and maintain teams in the integrated team structure.

[PA167.IG104.SP103]

The teams within the selected and satisfactory integrated team structure are established. This process encompasses the choosing of team leaders and the assignment of planned responsibilities and requirements for each team. It also involves providing the resources required to accomplish the tasks assigned to the team. [PA167.IG104.SP103.N101]

The integrated team structure is a dynamic entity that must be able to adjust to changes in people, requirements, and the nature of tasks, and to tackle many difficulties. The integrated team structure should be continuously monitored to detect malfunctions, mismanaged interfaces, and mismatches of the work to the staff. Corrective action should be taken when performance does not meet expectations. [PA167.IG104.SP103.N102]

Typical Work Products

1. A list of project integrated teams [PA167.IG104.SP103.W101]
2. List of team leaders [PA167.IG104.SP103.W102]
3. Responsibilities and authorities for each integrated team
[PA167.IG104.SP103.W103]
4. Requirements allocated to each integrated team [PA167.IG104.SP103.W104]
5. Measures for evaluating the performance of integrated teams
[PA167.IG104.SP103.W105]
6. Quality assurance reports [PA167.IG104.SP103.W106]
7. Periodic status reports [PA167.IG104.SP103.W107]
8. New integrated team structures [PA167.IG104.SP103.W108]

Subpractices

1. Choose integrated team leaders. [PA167.IG104.SP103.SubP101]

   Integrated team leaders are selected who can achieve the expectations of the product in the context of organizational limitations (project priority and the needs of other projects). Integrated teams need a great deal of autonomy to faithfully implement IPPD. That autonomy is at risk if project or organizational leadership does not have confidence in the leader. The extent of organizational and project direction in selecting the leader is often a function of product risk and complexity. It can also be related to an organization's need to "grow" new leaders. [PA167.IG104.SP103.SubP101.N101]

2. Allocate responsibilities and requirements to each integrated team. [PA167.IG104.SP103.SubP102]

   The planned responsibilities and requirements are issued to the integrated team. These items are discussed with the team to encourage collaborative buy-in. Some adjustments may be made at this time. [PA167.IG104.SP103.SubP102.N101]

3. Allocate resources to each integrated team. [PA167.IG104.SP103.SubP103]

   The people and other resources are allocated to each integrated team. These items are discussed with the team to ensure that the resources are adequate and that the people are adequate to carry out the tasks and are compatible with other members of the team. [PA167.IG104.SP103.SubP103.N101]

4. Create each integrated team. [PA167.IG104.SP103.SubP104]

   Refer to the Integrated Teaming process area for more information about forming and sustaining each of the integrated teams in the team structure. *[PA167.IG104.SP103.SubP104.R101]*

   For each integrated team in the selected structure, create a team that has a shared vision, charter, and operating principles as described in the Integrated Teaming process area. Creating the integrated team is a collaborative effort of the team sponsor and the members of the team. Other relevant stakeholders may be involved in accordance with the plan for stakeholder involvement. The teams that interface with the target team should be involved to ensure that the specified interfaces are honored. [PA167.IG104.SP103.SubP104.N101]

5. Integrated team composition and structures are periodically evaluated and modified to best reflect project needs. [PA167.IG104.SP103.SubP105]

   Changes in team structure could include: [PA167.IG104.SP103.SubP105.N101]

   - Retiring a team for a period of time (e.g., while long duration manufacturing or verifications are done)
   - Disbanding a team when it is no longer cost effective in serving the project
   - Combining teams to achieve operating efficiencies

- Adding teams as new product components are identified for development

6. When a change of team leader or a significant change of membership of the team occurs, review the integrated team composition and its place in the integrated team structure. [PA167.IG104.SP103.SubP106]

   A change of this kind may significantly affect the ability of the team to accomplish its objectives. A review of the match between the new composition and the current responsibilities should be made. If the match is not satisfactory, the team composition should be changed or the team's responsibility should be modified. One complication of changed responsibility is that other teams may have to adjust and add tasks to cover the change. This fact may cause a domino effect in the team structure. Such a change should be undertaken carefully. [PA167.IG104.SP103.SubP106.N101]

7. When a change in team responsibility occurs, review the team composition and its tasking. [PA167.IG104.SP103.SubP107]

   These changes often occur as the project moves from one phase to the next. For example, less design expertise on teams may be needed when detailed design is completed and fabrication and integration of product components begins. [PA167.IG104.SP103.SubP107.N101]

8. Manage the overall performance of the teams. [PA167.IG104.SP103.SubP108]

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the integrated project management process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for using the project's defined process and coordinating and collaborating with relevant stakeholders. [PA167.EL101]

For Integrated Product and Process Development

This policy also establishes organizational expectations for using Integrated Product and Process Development concepts for carrying out the objectives of the organization. *[PA167.EL111]*

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined integrated project management process. *[GP114]*

Elaboration:

This generic practice is different from the Establish the Project's Defined Process specific practice in this process area. This generic practice establishes and maintains a defined integrated project management process. The Establish the Project's Defined Process specific practice defines the project's defined process, which includes all processes that affect the project. [PA167.EL118]

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the integrated project management process. *[GP104]*

Elaboration:

Typically, this plan for performing the integrated project management process is a part of the project plan as described in the Project Planning process area. [PA167.EL107]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the integrated project management process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Examples of resources provided include the following tools: [PA167.EL102]

- Problem-tracking and trouble-reporting packages
- Groupware
- Video conferencing
- Integrated decision database
- Integrated product support environments

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the integrated project management process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the integrated project management process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA167.EL103]

- Tailoring the organization's set of standard processes to meet the needs of the project
- Procedures for managing the project based on the project's defined process
- Using the organization's measurement repository
- Using the organizational process assets
- Integrated management
- Intergroup coordination
- Group problem solving

For Integrated Product and Process Development

Examples of training topics also include the following: [PA167.EL112]

- *Building the project's shared vision*
- *Team building*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the integrated project management process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA167.EL104]

- The project's defined process
- Project plans
- Other plans that affect the project
- Integrated plans
- Actual process and product measures collected from the project

For Integrated Product and Process Development

Examples of work products placed under configuration management also include the following: [PA167.EL113]

- *Integrated team structure*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the integrated project management process as planned. [GP124]

Elaboration:

This generic practice is different from managing stakeholder involvement for the project, which is covered by specific practices within this process area. [PA167.EL108]

Examples of activities for stakeholder involvement include: [PA167.EL110]

- Resolving issues about the tailoring of the organizational process assets
- Resolving issues among the project plan and the other plans that affect the project
- Reviewing project performance to align with current and projected needs, objectives, and requirements

For Integrated Product and Process Development

Examples of activities for stakeholder involvement also include: [PA167.EL114]

- *Creating the project's shared vision*
- *Defining the integrated team structure for the project*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the integrated project management process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA167.EL105]

- Number of changes to the project's defined process
- Schedule and effort to tailor the organization's set of standard processes
- Interface coordination issue trends (i.e., number identified and number closed)

For Integrated Product and Process Development

Examples of measures used in monitoring and controlling also include the following: *[PA167.EL115]*

- *Project's shared-vision usage and effectiveness*
- *Integrated team-structure usage and effectiveness*
- *Select indicators of shared-vision effectiveness that show (1) that there is unity of purpose within the project, (2) that project members are working together and meeting the project's objectives, (3) that behaviors and principles have been established and are being used while team members work to achieve objectives, and (4) that the shared vision of the project aligns with the existing visions of the organization and other projects, particularly those with which close interaction is expected*

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the integrated project management process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Elaboration:

This generic practice is different from the Contribute to the Organizational Process Assets specific practice in this process area. This generic practice collects improvement information about the integrated project management processes. The Contribute to the Organizational Process Assets specific practice collects information from processes in the project's defined process. [PA167.EL119]

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the integrated project management process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA167.EL106]

- Establishing, maintaining, and using the project's defined process
- Coordinating and collaborating with relevant stakeholders

For Integrated Product and Process Development

Examples of activities reviewed also include the following: [PA167.EL116]

- *Using the project's shared vision*

Examples of work products reviewed include the following: [PA167.EL109]

- Project's defined process
- Project plans
- Other plans that affect the project

For Integrated Product and Process Development

Examples of work products reviewed also include the following: [PA167.EL117]

- *Integrated plans*
- *Shared-vision statements*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the integrated project management process with higher level management and resolve issues. *[GP112]*

RISK MANAGEMENT

Maturity Level 3

Purpose

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 across the life of the product or project to mitigate adverse impacts on achieving objectives. [PA148]

Introductory Notes

Risk management is a continuous, forward-looking process that is an important part of business and technical management processes. Risk management should address issues that could endanger achievement of critical objectives. A continuous risk management approach is applied to effectively anticipate and mitigate the risks that have critical impact on the project. [PA148.N101]

Effective risk management includes early and aggressive risk identification through the collaboration and involvement of relevant stakeholders, as described in the stakeholder involvement plan addressed in the Project Planning process area. Strong leadership across all relevant stakeholders is needed to establish an environment for the free and open disclosure and discussion of risk. [PA148.N102]

While technical issues are a primary concern both early on and throughout all project phases, risk management must consider both internal and external sources for cost, schedule, and technical risk. Early and aggressive detection of risk is important because it is typically easier, less costly, and less disruptive to make changes and correct work efforts during the earlier, rather than the later, phases of the project. [PA148.N103]

Risk management can be divided into three parts: defining a risk management strategy; identifying and analyzing risks; and handling identified risks, including the implementation of risk mitigation plans when needed. [PA148.N104]

As represented in the Project Planning and Project Monitoring and Control process areas, organizations may initially focus simply on risk identification for awareness, and react to the realization of these risks as they occur. The Risk Management process area describes an evolution of these specific practices to systematically plan, anticipate, and mitigate risks to proactively minimize their impact on the project. [PA148.N105]

Although the primary emphasis of the Risk Management process area is on the project, the concepts may also be applied to manage organizational risks. [PA148.N106]

Related Process Areas

Refer to the Project Planning Process Area for more information about identification of project risks and planning for involvement of relevant stakeholders. [PA148.R101]

Refer to the Project Monitoring and Control process area for more information about monitoring project risks. [PA148.R102]

Refer to the Decision Analysis and Resolution process area for more information about using a formal evaluation process to evaluate alternatives for selection and mitigation of identified risks. [PA148.R103]

Specific and Generic Goals

SG 1 **Prepare for Risk Management** [PA148.IG101]

Preparation for risk management is conducted.

SG 2 **Identify and Analyze Risks** [PA148.IG102]

Risks are identified and analyzed to determine their relative importance.

SG 3 **Mitigate Risks** [PA148.IG103]

Risks are handled and mitigated, where appropriate, to reduce adverse impacts on achieving objectives.

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Prepare for Risk Management [PA148.IG101]
- SP 1.1 Determine Risk Sources and Categories
- SP 1.2 Define Risk Parameters
- SP 1.3 Establish a Risk Management Strategy

SG 2 Identify and Analyze Risks [PA148.IG102]
- SP 2.1 Identify Risks
- SP 2.2 Evaluate, Categorize, and Prioritize Risks

SG 3 Mitigate Risks [PA148.IG103]
- SP 3.1 Develop Risk Mitigation Plans
- SP 3.2 Implement Risk Mitigation Plans

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 3.1	(AB 1)	Establish a Defined Process
GP 2.2	(AB 2)	Plan the Process
GP 2.3	(AB 3)	Provide Resources
GP 2.4	(AB 4)	Assign Responsibility
GP 2.5	(AB 5)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 3.2	(DI 4)	Collect Improvement Information
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

Specific Practices by Goal

SG 1 Prepare for Risk Management

Preparation for risk management is conducted. [PA148.IG101]

Preparation is conducted by establishing and maintaining a strategy for identifying, analyzing, and mitigating risks. This is typically documented in a risk management plan. The risk management strategy addresses the specific actions and management approach used to apply and control the risk management program. This includes identifying the sources of risk, the scheme used to categorize risks, and the parameters used to evaluate, bound, and control risks for effective handling. [PA148.IG101.N101]

SP 1.1 Determine Risk Sources and Categories

Determine risk sources and categories. [PA148.IG101.SP101]

Identification of risk sources provides a basis for systematically examining changing situations over time to uncover circumstances that impact the ability of the project to meet its objectives. Risk sources are both internal and external to the project. As the project progresses, additional sources of risk may be identified. Establishing categories for risks provides a mechanism for collecting and organizing risks as well as ensuring appropriate scrutiny and management attention for those risks that can have more serious consequences on meeting project objectives. [PA148.IG101.SP101.N101]

Typical Work Products

1. Risk source lists (external and internal) [PA148.IG101.SP101.W101]
2. Risk categories list [PA148.IG101.SP101.W102]

Subpractices

1. Determine risk sources. [PA148.IG101.SP101.SubP101]

   Risk sources are the fundamental drivers that cause risks within a project or organization. There are many sources of risks, both internal and external to a project. Risk sources identify common areas where risks may originate. Typical internal and external risk sources include the following: [PA148.IG101.SP101.SubP101.N101]

   - Uncertain requirements
   - Unprecedented efforts—estimates unavailable
   - Infeasible design
   - Unavailable technology
   - Unrealistic schedule estimates or allocation
   - Inadequate staffing and skills
   - Cost or funding issues
   - Uncertain or inadequate subcontractor capability
   - Uncertain or inadequate vendor capability

   Many of these sources of risk are often accepted without adequate planning. Early identification of both internal and external sources of risk can lead to early identification of risks. Risk mitigation plans can then be implemented early in the project to preclude occurrence of the risks or reduce the consequences of their occurrence. [PA148.IG101.SP101.SubP101.N102]

2. Determine risk categories. [PA148.IG101.SP101.SubP102]

   Risk categories reflect the "bins" for collecting and organizing risks. A reason for identifying risk categories is to help in the future consolidation of the activities in the risk mitigation plans. [PA148.IG101.SP101.SubP102.N101]

The following factors may be considered when determining risk categories: [PA148.IG101.SP101.SubP102.N102]

- The phases of the project's life-cycle model (e.g., requirements, design, manufacturing, test and evaluation, delivery, disposal)
- The types of processes used
- The types of products used
- Program management risks (e.g., contract risks, budget/cost risks, schedule risks, resources risks, performance risks, supportability risks)

A risk taxonomy can be used to provide a framework for determining risk sources and categories. [PA148.IG101.SP101.SubP102.N103]

SP 1.2 Define Risk Parameters

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

[PA148.IG101.SP102]

Parameters for evaluating, categorizing, and prioritizing risks include the following: [PA148.IG101.SP102.N101]

- Risk likelihood (i.e., probability of risk occurrence)
- Risk consequence (i.e., impact and severity of risk occurrence)
- Thresholds to trigger management activities

Risk parameters are used to provide common and consistent criteria for comparing the various risks to be managed. Without these parameters, it would be very difficult to gauge the severity of the unwanted change caused by the risk and to prioritize the necessary actions required for risk mitigation planning. [PA148.IG101.SP102.N102]

Typical Work Products

1. Risk evaluation, categorization, and prioritization criteria [PA148.IG101.SP102.W101]
2. Risk management requirements (control and approval levels, reassessment intervals, etc.) [PA148.IG101.SP102.W102]

Subpractices

1. Define consistent criteria for evaluating and quantifying risk likelihood and severity levels. [PA148.IG101.SP102.SubP101]

Consistently used criteria (e.g., the bounds on the likelihood and severity levels) allow the impacts of different risks to be commonly understood, to receive the appropriate level of scrutiny, and to obtain the management attention warranted. In managing dissimilar risks (for example, personnel safety versus environmental pollution), it is important to ensure consistency in end result (e.g., a high risk of environmental pollution is as important as a high risk to personnel safety). [PA148.IG101.SP102.SubP101.N101]

2. Define thresholds for each risk category. [PA148.IG101.SP102.SubP102]

For each risk category, thresholds can be established to determine acceptability or unacceptability of risks, prioritization of risks, or triggers for management action. [PA148.IG101.SP102.SubP102.N101]

Examples of thresholds include the following: [PA148.IG101.SP102.SubP102.N102]

- Project-wide thresholds could be established to involve senior management when product costs exceed 10% of the target cost or when Cost Performance Indexes (CPIs) fall below 0.95.
- Schedule thresholds could be established to involve senior management when Schedule Performance Indexes (SPIs) fall below 0.95.
- Performance thresholds could be set to involve senior management when specified key design items (e.g., processor utilization) exceed 125% of the intended design.

These may be refined later, for each identified risk, to establish points at which more aggressive risk monitoring is employed or to signal the implementation of risk mitigation plans. [PA148.IG101.SP102.SubP102.N105]

3. Define bounds on the extent to which thresholds are applied against or within a category. [PA148.IG101.SP102.SubP103]

There are few limits to which risks can be assessed in either a quantitative or qualitative fashion. Definition of bounds (or boundary conditions) can be used to help scope the extent of the risk management effort and avoid excessive resource expenditures. Bounds may include exclusion of a risk source from a category. These bounds may also exclude any condition that occurs less than a given frequency. [PA148.IG101.SP102.SubP103.N101]

SP 1.3 Establish a Risk Management Strategy

Establish and maintain the strategy to be used for risk management. *[PA148.IG101.SP103]*

A comprehensive risk management strategy addresses items such as the following: [PA148.IG101.SP103.N101]

- The scope of the risk management effort

- Methods and tools to be used for risk identification, risk analysis, risk mitigation, risk monitoring, and communication
- Project-specific sources of risks
- How these risks are to be organized, categorized, compared, and consolidated
- Parameters, including likelihood, consequence, and thresholds, for taking action on identified risks
- Risk mitigation techniques to be used, such as prototyping, simulation, alternative designs, or evolutionary development
- Definition of risk measures to monitor the status of the risks
- Time intervals for risk monitoring or reassessment

The risk management strategy should be guided by a common vision of success that describes the desired future project outcomes in terms of the product that is delivered, its cost, and its fitness for the task. The risk management strategy is often documented in an organizational or a project risk management plan. The risk management strategy is reviewed with relevant stakeholders to promote commitment and understanding. [PA148.IG101.SP103.N102]

Typical Work Products

1. Project risk management strategy [PA148.IG101.SP103.W101]

SG 2 Identify and Analyze Risks

Risks are identified and analyzed to determine their relative importance. *[PA148.IG102]*

The degree of risk impacts the resources assigned to handle an identified risk and the determination of when appropriate management attention is required. [PA148.IG102.N101]

Analyzing risks entails identifying risks from the internal and external sources identified and then evaluating each identified risk to determine its likelihood and consequences. Categorization of the risk, based on an evaluation against the established risk categories and criteria developed for the risk management strategy, provides the information needed for risk handling. Related risks may be grouped for efficient handling and effective use of risk management resources. [PA148.IG102.N102]

SP 2.1 Identify Risks

Identify and document the risks. *[PA148.IG102.SP101]*

For Integrated Product and Process Development

The particular risks associated with conducting the project using integrated teams should be considered, such as risks associated with loss of inter-team or intra-team coordination. [PA148.IG102.SP101.AMP101]

The identification of potential issues, hazards, threats, and vulnerabilities that could negatively affect work efforts or plans is the basis for sound and successful risk management. Risks must be identified and described in an understandable way before they can be analyzed and managed properly. Risks are documented in a concise statement that includes the context, conditions, and consequences of risk occurrence. [PA148.IG102.SP101.N101]

Risk identification should be an organized, thorough approach to seek out probable or realistic risks in achieving objectives. To be effective, risk identification should not be an attempt to address every possible event regardless of how highly improbable it may be. Use of the categories and parameters developed in the risk management strategy, along with the identified sources of risk, can provide the discipline and streamlining appropriate to risk identification. The identified risks form a baseline to initiate risk management activities. The list of risks should be reviewed periodically to reexamine possible sources of risk and changing conditions to uncover sources and risks previously overlooked or nonexistent when the risk management strategy was last updated. [PA148.IG102.SP101.N102]

Risk identification activities focus on the identification of risks, not placement of blame. The results of risk identification activities are not used by management to evaluate the performance of individuals. [PA148.IG102.SP101.N104]

There are many methods for identifying risks. Typical identification methods include the following: [PA148.IG102.SP101.N103]

- Examine each element of the project work breakdown structure to uncover risks.
- Conduct a risk assessment using a risk taxonomy.
- Interview subject matter experts.
- Review risk management efforts from similar products.
- Examine lessons-learned documents or databases.
- Examine design specifications and agreement requirements.

Typical Work Products

1. List of identified risks, including the context, conditions, and consequences of risk occurrence [PA148.IG102.SP101.W101]

Subpractices

1. Identify the risks associated with cost, schedule, and performance in all appropriate product life-cycle phases. [PA148.IG102.SP101.SubP101]

   Cost, schedule, and performance risks should be examined during all phases of the product life cycle to the extent they impact project objectives. There may be potential risks discovered that are outside the scope of the project's objectives but vital to customer interests. For example, the risks in development costs, product acquisition costs, cost of spare (or replacement) products, and product disposition (or disposal) costs have design implications. The customer may not have provided requirements for the cost of supporting the fielded product. The customer should be informed of such risks, but actively managing those risks may not be necessary. The mechanisms for making such decisions should be examined at project and organization levels and put in place if deemed appropriate, especially for risks that impact the ability to verify and validate the product.

   [PA148.IG102.SP101.SubP101.N101]

   In addition to the cost risks identified above, other cost risks may include those associated with funding levels, funding estimates, and distributed budgets.

   [PA148.IG102.SP101.SubP101.N102]

   Schedule risks may include risks associated with planned activities, key events, and milestones. [PA148.IG102.SP101.SubP101.N103]

   Performance risks may include risks associated with the following:

   [PA148.IG102.SP101.SubP101.N104]

   - Requirements
   - Analysis and design
   - Application of new technology
   - Physical size
   - Shape
   - Weight
   - Manufacturing and fabrication
   - Functional performance and operation
   - Verification
   - Validation
   - Performance maintenance attributes

   Performance maintenance attributes are those characteristics that enable an in-use product to provide originally required performance, such as maintaining safety and security performance. [PA148.IG102.SP101.SubP101.N105]

   There are other risks that do not fall into cost, schedule, or performance categories. [PA148.IG102.SP101.SubP101.N106]

Examples of these other risks include the following: [PA148.IG102.SP101.SubP101.N107]

- Risks associated with strikes
- Diminishing sources of supply
- Technology cycle time
- Competition

2. Review environmental elements that may impact the project. [PA148.IG102.SP101.SubP102]

   Risks to a project that frequently are missed include those supposedly outside the scope of the project (i.e., the project does not control whether they occur but can mitigate their impact), such as weather, natural disasters, political changes, and telecommunications failures. [PA148.IG102.SP101.SubP102.N101]

3. Review all elements of the work breakdown structure as part of identifying risks to help ensure that all aspects of the work effort have been considered. [PA148.IG102.SP101.SubP103]

4. Review all elements of the project plan as part of identifying risks to help ensure that all aspects of the project have been considered. [PA148.IG102.SP101.SubP104]

   Refer to the Project Planning process area for more information about identifying project risks. *[PA148.IG102.SP101.SubP104.R101]*

5. Document the context, conditions, and potential consequences of the risk. [PA148.IG102.SP101.SubP105]

   Risks statements are typically documented in a standard format that contains the risk context, conditions, and consequences of occurrence. The risk context provides additional information such that the intent of the risk can be easily understood. In documenting the context of the risk, consider the relative time frame of the risk, the circumstances or conditions surrounding the risk that has brought about the concern, and any doubt or uncertainty. [PA148.IG102.SP101.SubP105.N101]

6. Identify the relevant stakeholders associated with each risk. [PA148.IG102.SP101.SubP106]

SP 2.2 Evaluate, Categorize, and Prioritize Risks

Evaluate and categorize each identified risk using the defined risk categories and parameters, and determine its relative priority.

[PA148.IG102.SP102]

The evaluation of risks is needed to assign relative importance to each identified risk, and is used in determining when appropriate management attention is required. Often it is useful to aggregate risks based on their interrelationships, and develop options at an aggregate level. When an aggregate risk is formed by a roll up of lower level risks, care must be taken to ensure that important lower level risks are not ignored. [PA148.IG102.SP102.N101]

Collectively, the activities of risk evaluation, categorization, and prioritization are sometimes called "risk assessment" or "risk analysis." [PA148.IG102.SP102.N103]

Typical Work Products

1. List of risks, with a priority assigned to each risk [PA148.IG102.SP102.W101]

Subpractices

1. Evaluate the identified risks using the defined risk parameters. [PA148.IG102.SP102.SubP101]

   Each risk is evaluated and assigned values in accordance with the defined risk parameters, which may include likelihood, consequence (severity, or impact), and thresholds. The assigned risk parameter values can be integrated to produce additional measures, such as risk exposure, which can be used to prioritize risks for handling. [PA148.IG102.SP102.SubP101.N101]

   Often, a scale with three to five values is used to evaluate both likelihood and consequence. Likelihood, for example, can be categorized as remote, unlikely, likely, highly likely, or a near certainty. [PA148.IG102.SP102.SubP101.N102]

   Examples for consequences include the following: [PA148.IG102.SP102.SubP101.N104]

   - Low
   - Medium
   - High
   - Negligible
   - Marginal
   - Significant
   - Critical
   - Catastrophic

   Probability values are frequently used to quantify likelihood. Consequences are generally related to cost, schedule, environmental impact, or human measures (such as labor hours lost and severity of injury). [PA148.IG102.SP102.SubP101.N105]

This evaluation is often a difficult and time-consuming task. Specific expertise or group techniques may be needed to assess the risks and gain confidence in the prioritization. In addition, priorities may require reevaluation as time progresses. [PA148.IG102.SP102.SubP101.N103]

2. Categorize and group risks according to the defined risk categories. [PA148.IG102.SP102.SubP102]

   Risks are categorized into the defined risk categories, providing a means to look at risks according to their source, taxonomy, or project component. Related or equivalent risks may be grouped for efficient handling. The cause-and-effect relationships between related risks are documented. [PA148.IG102.SP102.SubP102.N101]

3. Prioritize risks for mitigation. [PA148.IG102.SP102.SubP103]

   A relative priority is determined for each risk, based on the assigned risk parameters. Clear criteria should be used to determine the risk priority. The intent of prioritization is to determine the most effective areas to which resources for mitigation of risks can be applied with the greatest positive impact to the project. [PA148.IG102.SP102.SubP103.N101]

SG 3 Mitigate Risks

Risks are handled and mitigated, where appropriate, to reduce adverse impacts on achieving objectives. *[PA148.IG103]*

The steps in handling risks include developing risk-handling options, monitoring risks, and performing risk-handling activities when defined thresholds are exceeded. Risk mitigation plans are developed and implemented for selected risks to proactively reduce the potential impact of risk occurrence. This may also include contingency plans to deal with the impact of selected risks that may occur despite attempts to mitigate them. The risk parameters used to trigger risk-handling activities are defined by the risk management strategy. [PA148.IG103.N101]

SP 3.1 Develop Risk Mitigation Plans

Develop a risk mitigation plan for the most important risks to the project, as defined by the risk management strategy. *[PA148.IG103.SP101]*

A critical component of a risk mitigation plan is to develop alternative courses of action, workarounds, and fallback positions, with a recommended course of action for each critical risk. The risk mitigation plan for a given risk includes techniques and methods used to avoid, reduce, and control the probability of occurrence of the risk, the extent of damage incurred should the risk occur (sometimes called a "contingency plan"), or both. Risks are monitored and when they exceed the established thresholds, the risk mitigation plans are deployed to return the impacted effort to an acceptable risk level. If the risk cannot be mitigated, a contingency plan may be invoked. Both risk mitigation and contingency plans are often generated only for selected risks where the consequences of the risks are determined to be high or unacceptable; other risks may be accepted and simply monitored. [PA148.IG103.SP101.N102]

Options for handling risks typically include alternatives such as the following: [PA148.IG103.SP101.N103]

- Risk avoidance: Changing or lowering requirements while still meeting the user's needs
- Risk control: Taking active steps to minimize risks
- Risk transfer: Reallocating design requirements to lower the risks
- Risk monitoring: Watching and periodically reevaluating the risk for changes to the assigned risk parameters
- Risk acceptance: Acknowledgment of risk but not taking any action

Often, especially for high risks, more than one approach to handling a risk should be generated. [PA148.IG103.SP101.N104]

In many cases, risks will be accepted or watched. Risk acceptance is usually done when the risk is judged too low for formal mitigation, or when there appears to be no viable way to reduce the risk. If a risk is accepted, the rationale for this decision should be documented. Risks are watched when there is an objectively defined, verifiable, and documented threshold of performance, time, or risk exposure (the combination of likelihood and consequence) that will trigger risk mitigation planning or invoke a contingency plan if it is needed. [PA148.IG103.SP101.N105]

Adequate consideration should be given early to technology demonstrations, models, simulations, and prototypes as part of risk mitigation planning. [PA148.IG103.SP101.N106]

Typical Work Products

1. Documented handling options for each identified risk [PA148.IG103.SP101.W101]
2. Risk mitigation plans [PA148.IG103.SP101.W102]

3. Contingency plans [PA148.IG103.SP101.W104]

4. List of those responsible for tracking and addressing each risk [PA148.IG103.SP101.W103]

Subpractices

1. Determine the levels and thresholds that define when a risk becomes unacceptable and triggers the execution of a risk mitigation plan or a contingency plan. [PA148.IG103.SP101.SubP101]

   Risk level (derived using a risk model) is a measure combining the uncertainty of reaching an objective with the consequences of failing to reach the objective. [PA148.IG103.SP101.SubP101.N101]

   Risk levels and thresholds that bound planned or acceptable performance must be clearly understood and defined to provide a means with which risk can be understood. Proper categorization of risk is essential for ensuring both appropriate priority, based on severity and the associated management response. There may be multiple thresholds employed to initiate varying levels of management response. Typically, thresholds for the execution of risk mitigation plans are set to engage before the execution of contingency plans. [PA148.IG103.SP101.SubP101.N102]

2. Identify the person or group responsible for addressing each risk. [PA148.IG103.SP101.SubP102]

3. Determine the cost-to-benefit ratio of implementing the risk mitigation plan for each risk. [PA148.IG103.SP101.SubP103]

   Risk mitigation activities should be examined for the benefits they provide versus the resources they will expend. Just like any other design activity, alternative plans may need to be developed and the costs and benefits of each alternative are assessed. The most appropriate plan is then selected for implementation. At times the risk may be significant and the benefits small, but the risk must be mitigated to reduce the probability of incurring unacceptable consequences. [PA148.IG103.SP101.SubP103.N101]

4. Develop an overall risk mitigation plan for the project to orchestrate the implementation of the individual risk mitigation and contingency plans. [PA148.IG103.SP101.SubP104]

   The complete set of risk mitigation plans may not be affordable. A tradeoff analysis should be performed to prioritize the risk mitigation plans for implementation. [PA148.IG103.SP101.SubP104.N101]

5. Develop contingency plans for selected critical risks in the event their impacts are realized. [PA148.IG103.SP101.SubP105]

Risk mitigation plans are developed and implemented as needed to proactively reduce risks before they become problems. Despite best efforts, some risks may be unavoidable and will become problems that impact the project. Contingency plans can be developed for critical risks to describe the actions a project may take to deal with the occurrence of this impact. The intent is to define a proactive plan for handling the risk, either to reduce the risk (mitigation) or respond to the risk (contingency), but in either event to manage the risk. [PA148.IG103.SP101.SubP105.N101]

Some risk management literature may consider contingency plans a synonym or subset of risk mitigation plans. These plans also may be addressed together as risk-handling or risk action plans. [PA148.IG103.SP101.SubP105.N102]

SP 3.2 Implement Risk Mitigation Plans

Monitor the status of each risk periodically and implement the risk mitigation plan as appropriate. *[PA148.IG103.SP102]*

To effectively control and manage risks during the work effort, follow a proactive program to regularly monitor risks and the status and results of risk-handling actions. The risk management strategy defines the intervals at which the risk status should be revisited. This activity may result in the discovery of new risks or new risk-handling options that may require re-planning and reassessment. In either event, the acceptability thresholds associated with the risk should be compared against the status to determine the need for implementing a risk mitigation plan. [PA148.IG103.SP102.N101]

Typical Work Products

1. Updated lists of risk status [PA148.IG103.SP102.W101]
2. Updated assessments of risk likelihood, consequence, and thresholds [PA148.IG103.SP102.W102]
3. Updated lists of risk-handling options [PA148.IG103.SP102.W103]
4. Updated list of actions taken to handle risks [PA148.IG103.SP102.W104]
5. Risk mitigation plans [PA148.IG103.SP102.W105]

Subpractices

1. Monitor risk status. [PA148.IG103.SP102.SubP101]

   After a risk mitigation plan is initiated, the risk is still monitored. Thresholds are assessed to check for the potential execution of a contingency plan. [PA148.IG103.SP102.SubP101.N101]

   A periodic mechanism for monitoring should be employed. [PA148.IG103.SP102.SubP101.N102]

2. Provide a method for tracking open risk-handling action items to closure. [PA148.IG103.SP102.SubP102]

Refer to the Project Monitoring and Control process area for more information about tracking action items. [PA148.IG103.SP102.SubP102.R101]

3. Invoke selected risk-handling options when monitored risks exceed the defined thresholds. [PA148.IG103.SP102.SubP103]

   Quite often, risk handling is only performed for those risks judged to be "high" and "medium." The risk-handling strategy for a given risk may include techniques and methods to avoid, reduce, and control the likelihood of the risk or the extent of damage incurred should the risk (anticipated event or situation) occur or both. In this context, risk handling includes both risk mitigation plans and contingency plans. [PA148.IG103.SP102.SubP103.N101]

   Risk-handling techniques are developed to avoid, reduce, and control adverse impact to project objectives and to bring about acceptable outcomes in light of probable impacts. Actions generated to handle a risk require proper resource loading and scheduling within plans and baseline schedules. This re-planning effort needs to closely consider the effects on adjacent or dependent work initiatives or activities. [PA148.IG103.SP102.SubP103.N102]

   Refer to the Project Monitoring and Control process area for more information about revising the project plan.
   [PA148.IG103.SP102.SubP103.N102.R101]

4. Establish a schedule or period of performance for each risk-handling activity that includes the start date and anticipated completion date. [PA148.IG103.SP102.SubP104]

5. Provide continued commitment of resources for each plan to allow successful execution of the risk-handling activities.
   [PA148.IG103.SP102.SubP105]

6. Collect performance measures on the risk-handling activities.
   [PA148.IG103.SP102.SubP106]

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the risk management process. [GP103]

Elaboration:

This policy establishes organizational expectations for defining a risk management strategy and identifying, analyzing, and mitigating risks. [PA148.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined risk management process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the risk management process. *[GP104]*

Elaboration:

Typically, this plan for performing the risk management process is included in (or referenced by) the project plan, which is described in the Project Planning process area. The plan for performing the risk management process differs from both the risk management strategy and the risk mitigation plans described in the specific practices in this process area. The plan called for in this generic practice would address the comprehensive planning for all of the specific practices in this process area, from determining risk sources and categories all the way through to the implementation of risk mitigation plans. In contrast, the risk management strategy called for in one specific practice would address the project-specific risk strategy for things such as risk sources, thresholds, tools, and techniques, and would monitor time intervals. The risk mitigation plans called for in another specific practice would address more focused items such as the levels that trigger risk-handling activities. [PA148.EL103]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the risk management process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Examples of resources provided include the following tools: [PA148.EL106]

- Risk management databases
- Risk mitigation tools
- Prototyping tools
- Modeling and simulation

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the risk management process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the risk management process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA148.EL108]

- Risk management concepts and activities (e.g., risk identification, evaluation, monitoring, mitigation)
- Measure selection for risk mitigation

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the risk management process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA148.EL110]

- Risk management strategy
- Identified risk items
- Risk mitigation plans

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the risk management process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include the following: [PA148.EL120]

- Establishing a collaborative environment for free and open discussion of risk
- Reviewing the risk management strategy and risk mitigation plans
- Participating in risk identification, analysis, and mitigation activities
- Communicating and reporting risk management status

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the risk management process against the plan for performing the process and take appropriate corrective action.

[GP110]

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA148.EL113]

- Number of risks identified, managed, tracked, and controlled
- Risk exposure and changes to the risk exposure for each assessed risk, and as a summary percentage of management reserve
- Change activity for the risk mitigation plans (e.g., processes, schedule, funding)
- Occurrence of unanticipated risks
- Risk categorization volatility
- Comparison of estimated vs. actual risk mitigation effort and impact

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the risk management process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the risk management process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA148.EL116]

- Establishing and maintaining a risk management strategy
- Identifying and analyzing risks
- Mitigating risks

Examples of work products reviewed include the following: [PA148.EL117]

- Risk management strategy
- Risk mitigation plans

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the risk management process with higher level management and resolve issues. *[GP112]*

Elaboration:

Reviews of the project risk status are held on a periodic and event-driven basis with appropriate levels of management, to provide visibility into the potential for project risk exposure and appropriate corrective action. [PA148.EL118]

Typically, these reviews will include a summary of the most critical risks, key risk parameters (such as likelihood and consequence of these risks), and the status of risk mitigation efforts. [PA148.EL119]

INTEGRATED TEAMING

Maturity Level 3

Purpose

The purpose of Integrated Teaming is to form and sustain an integrated team for the development of work products. [PA170]

Introductory Notes

Integrated team members: [PA170.N101]

- provide the needed skills and expertise to accomplish the team's tasks
- provide the advocacy and representation necessary to address all essential phases of the product's life cycle
- collaborate internally and externally with other teams and relevant stakeholders as appropriate
- share a common understanding of the team's tasks and objectives
- conduct themselves in accordance with established operating principles and ground rules

An integrated team (also known as an "Integrated Product Team" or IPT) is composed of relevant stakeholders who generate and implement decisions for the work product being developed. The members of the integrated team are collectively responsible for delivering the work product. See the definition of "integrated team" in Appendix C: Glossary. The integrated team receives its assignment from its sponsor. The sponsor of an integrated team is a person or a group (e.g., project manager or even another integrated team) who can assign work tasks and provide resources. [PA170.N102]

The following characteristics distinguish an integrated team in an Integrated Product and Process Development (IPPD) environment from other forms of specialty work or task groups: [PA170.N103]

- Team members include empowered representatives from both technical and business functional organizations involved with the product. Within defined boundaries, these representatives have decision-making authority and the responsibility to act for their respective organizations.
- Team members may include customers, suppliers, and other stakeholders outside of the organization as appropriate to the product being developed.

- An integrated team consists of people skilled in the functions that need to be performed to develop required work products. Some of them may represent a functional organization. These people have a dual responsibility to focus on the product while maintaining their connections with the functional organization that can assist the development with additional expertise and advice.
- An integrated team focuses on the product life cycle to the extent required by the project. Team members share and integrate considerations, expectations, and requirements of the product life-cycle phases.
- An integrated team understands its role in the structure of teams for the overall project.

Clearly defined and commonly understood objectives, tasks, responsibilities, authority, and context (of vertical and horizontal interfaces) provide a strong basis for implementing integrated teams. [PA170.N104]

Related Process Areas

Refer to the Project Planning process area for more information about planning for project execution within an IPPD environment where integrated teaming is involved. [PA170.R101]

Refer to the Organization Environment for Integration process area for more information about establishing and maintaining an integrated work environment and creating organizational process assets for IPPD, including an organization's shared vision. [PA170.R102]

Refer to the Integrated Project Management for IPPD process area for more information about coordinating and collaborating with relevant stakeholders, establishing the team structure, and considering IPPD organizational process assets. [PA170.R103]

Specific and Generic Goals

SG 1 Establish Team Composition [PA170.IG101]

A team composition that provides the knowledge and skills required to deliver the team's product is established and maintained.

SG 2 Govern Team Operation [PA170.IG102]

Operation of the integrated team is governed according to established principles.

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Establish Team Composition [PA170.IG101]

- SP 1.1 Identify Team Tasks
- SP 1.2 Identify Needed Knowledge and Skills
- SP 1.3 Assign Appropriate Team Members

SG 2 Govern Team Operation [PA170.IG102]

- SP 2.1 Establish a Shared Vision
- SP 2.2 Establish a Team Charter
- SP 2.3 Define Roles and Responsibilities
- SP 2.4 Establish Operating Procedures
- SP 2.5 Collaborate among Interfacing Teams

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 3.1	(AB 1)	Establish a Defined Process
GP 2.2	(AB 2)	Plan the Process
GP 2.3	(AB 3)	Provide Resources
GP 2.4	(AB 4)	Assign Responsibility
GP 2.5	(AB 5)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 3.2	(DI 4)	Collect Improvement Information
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

Specific Practices by Goal

SG 1 Establish Team Composition

A team composition that provides the knowledge and skills required to deliver the team's product is established and maintained. [PA170.IG101]

One of the main attributes of an integrated team is to be self managed and empowered. Team membership is intended to be composed of people who can plan, execute, and implement decisions for all phases of the life cycle of the work product being acquired or developed. Team member selection and skill mix should be based on the assigned work product and the objectives that are important to the different phases of that product's life cycle. Integrated teams should be cross functional and involve relevant stakeholders. [PA170.IG101.N101]

SP 1.1 Identify Team Tasks

Identify and define the team's specific internal tasks to generate the team's expected output. *[PA170.IG101.SP101]*

The sponsor of an integrated team typically provides the assigned product requirements, the initial technical and business interfaces, and the high-level task(s) each team will be responsible for satisfying. Integrated team tasks are based on these product requirements and interfaces. An integrated team understands its relationship to both the project and the organization, and structures its tasks accordingly to develop the work products. [PA170.IG101.SP101.N101]

Typical Work Products

1. Descriptions of internal work tasks [PA170.IG101.SP101.W101]
2. List of results the team is expected to achieve for all work tasks [PA170.IG101.SP101.W102]

Subpractices

1. Define team tasks required to deliver the assigned work products. [PA170.IG101.SP101.SubP101]
2. Decide which tasks need team or individual member input. [PA170.IG101.SP101.SubP102]

   Not all work efforts require the entire team; however, review and judgment are team responsibilities. [PA170.IG101.SP101.SubP102.N101]

SP 1.2 Identify Needed Knowledge and Skills

Identify the knowledge, skills, and functional expertise needed to perform team tasks. *[PA170.IG101.SP102]*

Refer to the Plan for Needed Knowledge and Skills specific practice in the Project Planning process area. Staffing a team is similar to staffing a project, just at a lower level. *[PA170.IG101.SP102.R101]*

The functional knowledge and related job skills within the integrated team are directly related to specific team tasks and responsibilities. A fully effective integrated team is able to perform its tasks and is composed of the necessary technical and business specialties and expertise. An integrated team advocates appropriate coverage for all phases of the work product life cycle. A profile of essential skill mixes that are required at all team functions describes the core team, which can be supplemented with additional skill sets as needed for the extended team. [PA170.IG101.SP102.N101]

Typical Work Products

1. List of disciplines or functions required to perform the tasks [PA170.IG101.SP102.W101]
2. List of the knowledge, key skills, and critical expertise [PA170.IG101.SP102.W102]
3. Initial profiles of team skills and knowledge for the core team and the extended team [PA170.IG101.SP102.W103]

Subpractices

1. Identify the business functions and processes in which the integrated team must maintain competence to perform its objectives. [PA170.IG101.SP102.SubP101]
2. Identify the core competencies on which to base the integrated team's activities to sustain or achieve desired capability. [PA170.IG101.SP102.SubP102]
3. Establish knowledge and skill profiles underlying each core and extended team competency. [PA170.IG101.SP102.SubP103]
4. Define staffing and competency requirements. [PA170.IG101.SP102.SubP104]

SP 1.3 Assign Appropriate Team Members

Assign the appropriate personnel to be team members based on required knowledge and skills. *[PA170.IG101.SP103]*

Team members are selected and positioned to perform team tasks based on their ability to satisfy required knowledge, skills, and functional expertise, and complement those of other team members. Team membership may not stay the same throughout the integrated team's period of performance. Selecting and assigning appropriate new members to the team to perform team tasks is an important element in maintaining proper team composition and output as members leave, team expectations change, or the team has evolved to the point where a different mix of personnel is necessary. [PA170.IG101.SP103.N101]

Examples of relevant criteria for evaluating potential team members include:
[PA170.IG101.SP103.N102]

- Knowledge and skills related to tasks and responsibilities associated with the team's assigned work products
- Interpersonal skills and ability to work in a team environment
- Ability to complement the mix of knowledge and skills in the team
- Potential to fulfill a significant responsibility on the team
- Ability to acquire additional knowledge, skills, or expertise related to the team's tasks
- Existing workload and time available to fulfill responsibilities to the team
- Educational and cultural background
- Personal (self) motivation
- Ability to represent a functional area appropriately

Individual team members are empowered, within defined limits, by their respective functional managers to make decisions. Team members can be selected from both within or outside of the organization and can include suppliers, customers, and end users. Their roles and responsibilities in team operation need to be clearly defined.
[PA170.IG101.SP103.N103]

Typical Work Products

1. Set of selection criteria [PA170.IG101.SP103.W101]
2. Revised skills matrix and knowledge profiles [PA170.IG101.SP103.W102]
3. List of team members [PA170.IG101.SP103.W103]
4. List of the level of effort and resources, including access to staff, to perform each team function [PA170.IG101.SP103.W104]

Subpractices

1. Establish relevant criteria for evaluating team members against established knowledge and skills profiles. [PA170.IG101.SP103.SubP101]
2. Utilize the criteria to qualify appropriate candidates against the knowledge and skills profiles. [PA170.IG101.SP103.SubP102]
3. Identify and orient team members to best contribute to the team's capability. [PA170.IG101.SP103.SubP103]
4. Assess and determine the integrated team's capability to meet its objectives based on initial staffing and positioning.
[PA170.IG101.SP103.SubP104]

It may be required to supplement the team's internal capability with external sources to maximize the team's ability to perform its function.

[PA170.IG101.SP103.SubP104.N101]

SG 2 Govern Team Operation

Operation of the integrated team is governed according to established principles. *[PA170.IG102]*

An integrated team operates in a disciplined way that brings about effectiveness and productivity in meeting its objectives. Established operating principles help both the team leader and team members to manage group dynamics and to ensure successful interplay among the multiple functions within the team. [PA170.IG102.N101]

SP 2.1 Establish a Shared Vision

Establish and maintain a shared vision for the integrated team that is aligned with any overarching or higher level vision. *[PA170.IG102.SP101]*

Refer to the Provide IPPD Infrastructure specific goal in the Organizational Environment for Integration process area for more information on the organization's shared vision. *[PA170.IG102.SP101.R101]*

Refer to the Use the Project's Shared Vision for IPPD specific goal in the Integrated Project Management for IPPD process area for more information about the project's shared vision. *[PA170.IG102.SP101.R102]*

The purpose of a shared vision is to provide a statement of an envisioned future and establish common understanding of the aspirations and governing ideals of the team in the context of that desired end state. The shared vision anchors the team's governing ideas and principles and captures the objectives to be achieved. The shared vision guides the activities of the team and helps drive the team to achieve its mission and objectives. A shared vision facilitates working together and helps the team to attain unity of purpose among its members. [PA170.IG102.SP101.N101]

No team operates in isolation. A shared vision for the integrated team is critical to ensure that the team's charter, direction, and activities achieve a fit with any larger project objectives or other interfacing teams. A team's sponsor(s) or leader may establish the vision for the organization or project for which the integrated team is a part. An integrated team's shared vision must be aligned with and support the achievement of the project's and organization's higher level objectives as well as its own. When one team falls short of or strays from its objectives and vision, it is likely to have a significant impact on the overall success of the project. [PA170.IG102.SP101.N102]

Shared-vision context has both an external and internal aspect. The external aspect entails the objectives and interfaces of the team's sponsor and overall organization, while the internal aspect is about aligning the group member's personal interests and vision with the team's mission and purpose. The shared vision must ensure a commitment of the integrated team members to both their team and to other interfacing teams and project responsibilities. [PA170.IG102.SP101.N103]

Aligning personal perceptions of the people within the team is an important part of understanding and accepting the shared vision. As such, a shared vision is usually not the product of one person's effort; however, the team's sponsor(s) or leader may begin the discussion of the vision for a team. It is important that all integrated team members understand and commit to a shared vision. The team population should openly discuss and be given the opportunity to provide feedback on the vision and address inconsistencies and make revisions as appropriate. This openness creates a vision that belongs to everyone, provides an end-state view of the implementation of the team's responsibilities, is the basis for the team's charter, and is applied to all work. Benefits of a shared vision are that people understand and can adopt its principles to guide their own, as well as the whole team's, actions and decisions. [PA170.IG102.SP101.N104]

Typical Work Products

1. Boundary conditions and interfaces within which the team must operate [PA170.IG102.SP101.W102]
2. Documented shared vision [PA170.IG102.SP101.W103]
3. Presentation materials of the shared-vision statement suitable for team members and various audiences that need to be informed [PA170.IG102.SP101.W104]

Subpractices

1. Convey the shared-vision context to team members to align personal aspirations and objectives with the team's expectations and envisioned future outcome. [PA170.IG102.SP101.SubP101]
2. Conduct meetings or workshops to discuss the shared vision. [PA170.IG102.SP101.SubP102]
3. Articulate the shared vision in terms of both core ideology and the desired future end state that each member can commit to. [PA170.IG102.SP101.SubP103]
4. Reinforce the relevance of the shared vision in performing individual and team activities and tasks. [PA170.IG102.SP101.SubP104]
5. Check the effectiveness of the shared vision and that individual and team activities or tasks are aligned with the shared vision. [PA170.IG102.SP101.SubP105]

6. Periodically reexamine clarity and applicability of the shared vision and revise or realign as necessary to better meet the current state of the team or project. [PA170.IG102.SP101.SubP106]

SP 2.2 Establish a Team Charter

Establish and maintain a team charter based on the integrated team's shared vision and overall team objectives. *[PA170.IG102.SP102]*

The team charter is the contract among the team members and between the team and its sponsor for the expected work effort and level of performance. Charters solidify the rights, guarantees, privileges, and permissions for organizing and performing the team's objectives and tasks. Development of the team charter is a negotiated activity between the sponsor of the team and the integrated team. When approved by both the team and the sponsor, the team charter constitutes a recognized agreement with management authority. The complexity of the team charter can vary depending on the scope of effort and the team objectives. Team objectives may be directly related to the assigned product requirements from the sponsor, specific project requirements, or identified internal team tasks. The charter typically identifies team responsibilities and authority and the measures by which the team's progress will be evaluated. [PA170.IG102.SP102.N101]

It is important that integrated teams exercise a level of authority in managing their activities and in making decisions in pursuit of their objectives. Team members need to assess whether the amount of power and control over decisions and actions has been properly delegated from upper management. The team decides whether the decision-making authority is appropriate to meet expectations and accomplish the tasks accepted by the team. The team negotiates any disagreements with the organizations or entities that assigned them. [PA170.IG102.SP102.N102]

Typical Work Products

1. Team charter [PA170.IG102.SP102.W101]
2. Procedures for setting the expectations for the work to be done and for measuring team performance [PA170.IG102.SP102.W102]
3. List of critical success factors [PA170.IG102.SP102.W103]
4. List of specific strategies the team expects to employ [PA170.IG102.SP102.W104]

Subpractices

1. Define and list the team objectives. [PA170.IG102.SP102.SubP101]

2. Identify specific strategies for achieving the team objectives.
[PA170.IG102.SP102.SubP102]

3. Establish the team's level of empowerment and independence.
[PA170.IG102.SP102.SubP103]

   Empowerment is not likely to be unlimited. Every team must operate within some constraints, and these limits on authority must be identified and defined up front.
[PA170.IG102.SP102.SubP103.N101]

   Refer to the Manage People for Integration specific goal in the Organizational Environment for Integration process area for more information on the organization's guidelines for the degree of empowerment for people and integrated teams.
[PA170.IG102.SP102.SubP103.N101.R101]

4. Identify how team and individual performance and accomplishments are measured. [PA170.IG102.SP102.SubP104]

   Refer to the Organizational Environment for Integration process area for more information about recognizing team as well as individual accomplishments. *[PA170.IG102.SP102.SubP104.R101]*

5. Identify critical success factors. [PA170.IG102.SP102.SubP105]

SP 2.3 Define Roles and Responsibilities

Clearly define and maintain each team member's roles and responsibilities. *[PA170.IG102.SP103]*

Defined roles and responsibilities provide clear understanding of the team members' contributions, level of involvement, interfaces (with team members and other teams or groups), and the degree of influence or control each member has on the success and functioning of the team. Allocation of roles and responsibilities should be based on each member's abilities, skills, and other commitments. Roles and responsibilities include the following: [PA170.IG102.SP103.N101]

- Establish and maintain interfaces among integrated team members
- Determine how assignments are accepted
- Determine how resources and input are accessed
- Determine how work gets done
- Determine who checks and reviews work
- Determine how work is approved
- Determine how work is delivered and communicated
- Maintain interfaces with their functional area

Typical Work Products

1. Descriptions of roles and responsibilities [PA170.IG102.SP103.W101]
2. Assignment statements [PA170.IG102.SP103.W102]
3. Responsibility matrix [PA170.IG102.SP103.W103]

Subpractices

1. Map the roles, responsibilities, and expertise of the team members to the team tasks and expected deliverables. [PA170.IG102.SP103.SubP101]

   Ensure that assignments are made to integrate complementary knowledge and skills. [PA170.IG102.SP103.SubP101.N101]

2. Define the working relationship and reporting structure for team members. [PA170.IG102.SP103.SubP102]

   Team members may have the responsibility to report to both the team leader and a functional organization and management chain. [PA170.IG102.SP103.SubP102.N101]

SP 2.4 Establish Operating Procedures

Establish and maintain integrated team operating procedures.
[PA170.IG102.SP104]

Operating procedures and ground rules serve to define and control how the team will interact and work together and to promote effective integration of efforts, high performance, and productivity for accomplishing objectives. Members especially need to understand the intended standards for work and to participate according to those precepts. [PA170.IG102.SP104.N101]

Typical Work Products

1. Operating procedures and ground rules [PA170.IG102.SP104.W101]
2. Procedures for work expectations and performance measures [PA170.IG102.SP104.W102]

Subpractices

1. Define the expectations and rules that will guide how the team works collectively and what the team members will use to moderate participation and interpersonal interaction. [PA170.IG102.SP104.SubP101]
2. Define the degree of collective decision making and level of consensus needed for team decisions. [PA170.IG102.SP104.SubP102]

   Refer to the Organizational Environment for Integration process area for more information about establishing a process for setting the context for decision making. *[PA170.IG102.SP104.SubP102.R101]*

3. Define how conflicts and differences of opinion within the team are addressed and resolved. [PA170.IG102.SP104.SubP103]

Refer to the Organizational Environment for Integration process area for more information about establishing a process for resolving conflicts and differences of opinion.
[PA170.IG102.SP104.SubP103.R101]

SP 2.5 Collaborate among Interfacing Teams

Establish and maintain collaboration among interfacing teams.
[PA170.IG102.SP105]

The success of a team-based project will be a function of how effectively and successfully the integrated teams collaborate with each other while achieving their own and the project's objectives.
[PA170.IG102.SP105.N101]

Refer to the Integrated Project Management for IPPD process area for more information about operating in an integrated environment, and about coordinating and collaborating with relevant stakeholders.
[PA170.IG102.SP105.N101.R101]

Typical Work Products

1. Work product and process deployment charts [PA170.IG102.SP105.W101]
2. Input to the integrated master plan and integrated schedules [PA170.IG102.SP105.W102]
3. Team work plans [PA170.IG102.SP105.W103]
4. Commitment lists [PA170.IG102.SP105.W104]

Subpractices

1. Collaboratively establish and maintain the work product ownership boundaries among interfacing teams within the project or organization. [PA170.IG102.SP105.SubP101]
2. Collaboratively establish and maintain interfaces and processes among interfacing teams for the exchange of inputs, outputs, or work products. [PA170.IG102.SP105.SubP102]

   Refer to the Integrated Project Management for IPPD process area for more information about coordinating and collaborating with relevant stakeholders. *[PA170.IG102.SP105.SubP102.R101]*
3. Collaboratively develop, communicate, and distribute among interfacing teams the commitment lists and work plans that are related to the work product or team interfaces. [PA170.IG102.SP105.SubP103]

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the integrated teaming process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for establishing and maintaining team composition and governing team operation. [PA170.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined integrated teaming process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the integrated teaming process. *[GP104]*

Elaboration:

Typically, this plan for performing the integrated teaming process is a part of the project plan as described in the Project Planning process area. [PA170.EL102]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the integrated teaming process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Examples of special equipment and facilities include: [PA170.EL103]

- Team war rooms (for regular strategy development and communication meetings)

Examples of other resources provided include the following tools: [PA170.EL104]

- Interactive electronic communication and data presentation tools (groupware)
- Team-building tools

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the integrated teaming process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the integrated teaming process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA170.EL105]

- Use of integrated work environments
- Interpersonal skills
- Communication skills
- Team building
- Collaborative problem solving and decision making

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the integrated teaming process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA170.EL106]

- List of team members
- List of the level of effort and resources, including access to staff, to perform each team function
- Work task formal commitment lists
- Team shared-vision statement
- Team charter

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the integrated teaming process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include the following: [PA170.EL107]

- Establishing and maintaining the team's shared vision
- Establishing and maintaining the team's charter
- Establishing and maintaining the team's operating procedures
- Collaborating with interfacing teams

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the integrated teaming process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA170.EL108]

- Performance according to plans, commitments, and procedures for the integrated team, and deviations from expectations
- Ability to achieve team objectives

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the integrated teaming process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the integrated teaming process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA170.EL109]

- Defined roles and responsibilities
- Communication activities within and among integrated teams

Examples of work products reviewed include the following: [PA170.EL110]

- Descriptions of roles and responsibilities
- Descriptions of product ownership boundaries and team interfaces

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the integrated teaming process with higher level management and resolve issues. *[GP112]*

DECISION ANALYSIS AND RESOLUTION

Maturity Level 3

Purpose

The purpose of Decision Analysis and Resolution is to analyze possible decisions using a formal evaluation process that evaluates identified alternatives against established criteria. [PA156]

Introductory Notes

The Decision Analysis and Resolution process area involves establishing guidelines to determine which issues should be subjected to a formal evaluation process and then applying formal evaluation processes to these issues. [PA156.N101]

A formal evaluation process is a structured approach to evaluating alternative solutions against established criteria to determine a recommended solution to address an issue. A formal evaluation process involves the following actions: [PA156.N112]

- Establishing the criteria for evaluating alternatives
- Identifying alternative solutions
- Selecting methods for evaluating alternatives
- Evaluating the alternative solutions using the established criteria and methods
- Selecting recommended solutions from the alternatives based on the evaluation criteria

Rather than using the phrase "alternative solutions to address issues" each time it is needed, we will use one of two shorter phrases: "alternative solutions" or "alternatives." [PA156.N113]

A formal evaluation process reduces the subjective nature of the decision and has a higher probability of selecting a solution that meets the multiple demands of the relevant stakeholders. [PA156.N102]

While the primary application of this process area is for selected technical concerns, formal evaluation processes can also be applied to many nontechnical issues, particularly when a project is being planned. Issues that have multiple alternative solutions and evaluation criteria lend themselves to a formal evaluation process. [PA156.N103]

Trade studies of equipment or software are typical examples of formal evaluation processes. [PA156.N111]

During planning, specific issues requiring a formal evaluation process are identified. Typical issues include selection among architectural or design alternatives, use of reusable or commercial off-the-shelf (COTS) components, supplier selection, engineering support environments or associated tools, test environments, and logistics and production. A formal evaluation process can also be used to address a make-or-buy decision, the development of manufacturing processes, the selection of distribution locations, and other decisions. [PA156.N104]

Guidelines are created for deciding when to use formal evaluation processes to address unplanned issues. Guidelines often suggest using formal evaluation processes when issues are associated with medium to high risks or when issues affect the ability to achieve project objectives. [PA156.N106]

Formal evaluation processes can vary in formality, type of criteria, and methods employed. Less formal decisions can be analyzed in a few hours, use only a few criteria (e.g., effectiveness and cost to implement), and result in a one- or two-page report. More formal decisions may require separate plans, months of effort, meetings to develop and approve criteria, simulations, prototypes, piloting, and extensive documentation. [PA156.N107]

Both numeric and non-numeric criteria can be used in a formal evaluation process. Numeric criteria use weights to reflect the relative importance of the criteria. Non-numeric criteria use a more subjective ranking scale (e.g., high, medium, low). More formal decisions may require a full trade study. [PA156.N108]

A formal evaluation process identifies and evaluates alternative solutions. The eventual selection of a solution may involve iterative activities of identification and evaluation. Portions of identified alternatives may be combined, emerging technologies may change alternatives, and the business situation for vendors may change during the evaluation period. [PA156.N109]

A recommended alternative is accompanied by documentation of the selected methods, criteria, alternatives, and rationale for the recommendation. The documentation is distributed to the relevant stakeholders; it provides a record of the formal evaluation process and rationale that is useful to other projects that encounter a similar issue. [PA156.N110]

Related Process Areas

Refer to the Project Planning process area for more information about general planning for projects. [PA156.R101]

Refer to the Integrated Project Management process area for more information about establishing the project's defined process. The project's defined process includes a formal evaluation process for each selected issue and incorporates the use of guidelines for applying a formal evaluation process to unforeseen issues. [PA156.R102]

Refer to the Risk Management process area for more information about identifying and mitigating risks. A formal evaluation process is often used to address issues with identified medium or high risks. Selected solutions typically affect risk mitigation plans. [PA156.R103]

Specific and Generic Goals

SG 1 Evaluate Alternatives [PA156.IG101]

Decisions are based on an evaluation of alternatives using established criteria.

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Evaluate Alternatives [PA156.IG101]

SP 1.1	Establish Guidelines for Decision Analysis
SP 1.2	Establish Evaluation Criteria
SP 1.3	Identify Alternative Solutions
SP 1.4	Select Evaluation Methods
SP 1.5	Evaluate Alternatives
SP 1.6	Select Solutions

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 3.1	(AB 1)	Establish a Defined Process
GP 2.2	(AB 2)	Plan the Process
GP 2.3	(AB 3)	Provide Resources
GP 2.4	(AB 4)	Assign Responsibility
GP 2.5	(AB 5)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 3.2	(DI 4)	Collect Improvement Information

GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

Specific Practices by Goal

SG 1 Evaluate Alternatives

Decisions are based on an evaluation of alternatives using established criteria. *[PA156.IG101]*

Issues requiring a formal evaluation process may be identified during any phase of a product or project life cycle. The objective should be to identify issues as early as possible to maximize the time available to resolve the issue. [PA156.IG101.N101]

SP 1.1 Establish Guidelines for Decision Analysis

Establish and maintain guidelines to determine which issues are subject to a formal evaluation process. *[PA156.IG101.SP101]*

Not every decision is significant enough to require a formal evaluation process. The choice between the trivial and the truly important will be unclear without explicit guidance. Whether a decision is significant or not is dependent on the project and circumstances, and is determined by the established guidelines. [PA156.IG101.SP101.N101]

Typical guidelines for determining when to require a formal evaluation process include the following: [PA156.IG101.SP101.N102]

- When a decision is directly related to topics assessed as being of medium or high risk
- When a decision is related to changing work products under configuration management
- When a decision would cause schedule delays over a certain percentage or specific amount of time
- When a decision affects the ability to achieve project objectives
- When the costs of the formal evaluation process are reasonable when compared to the decision's impact

Refer to the Risk Management process area for more information about determining which issues are medium or high risk. *[PA156.IG101.SP101.N102.R101]*

Examples of when to use a formal evaluation process include the following:
[PA156.IG101.SP101.N103]

- On material procurement when 20 percent of the material parts constitute 80 percent of the total material costs
- On design-implementation decisions when technical performance failure may cause a catastrophic failure (e.g., safety of flight item)
- On decisions with the potential to significantly reduce design risk, engineering changes, cycle time, and production costs (e.g., to use lithography models to assess form and fit capability before releasing engineering drawings and production builds)

Typical Work Products

1. Guidelines for when to apply a formal evaluation process
   [PA156.IG101.SP101.W101]

Subpractices

1. Establish guidelines. [PA156.IG101.SP101.SubP101]
2. Incorporate the use of the guidelines into the defined process where appropriate. [PA156.IG101.SP101.SubP102]

   Refer to the Integrated Project Management process area for more information about establishing the project's defined process.
   [PA156.IG101.SP101.SubP102.R101]

SP 1.2 Establish Evaluation Criteria

Establish and maintain the criteria for evaluating alternatives, and the relative ranking of these criteria. *[PA156.IG101.SP103]*

The evaluation criteria provide the basis for evaluating alternative solutions. The criteria are ranked so that the highest ranked criteria exert the most influence on the evaluation. [PA156.IG101.SP103.N101]

This process area is referenced by many other process areas in the model, and there are many contexts in which a formal evaluation process can be used. Therefore, in some situations you may find that criteria have already been defined as part of another process. This specific practice does not suggest that a second development of criteria be conducted. [PA156.IG101.SP103.N103]

Document the evaluation criteria to minimize the possibility that decisions will be second-guessed, or that the reason for making the decision will be forgotten. Decisions based on criteria that are explicitly defined and established remove barriers to stakeholder buy-in.
[PA156.IG101.SP103.N102]

Typical Work Products

1. Documented evaluation criteria [PA156.IG101.SP103.W101]
2. Rankings of criteria importance [PA156.IG101.SP103.W102]

Subpractices

1. Define the criteria for evaluating alternative solutions.
   [PA156.IG101.SP103.SubP101]

   Criteria should be traceable to requirements, scenarios, business case assumptions, business objectives, or other documented sources.
   [PA156.IG101.SP103.SubP101.N101]

   Types of criteria to consider include the following: [PA156.IG101.SP103.SubP101.N102]

   - Technology limitations
   - Environmental impact
   - Risks
   - Total ownership and life-cycle costs

2. Define the range and scale for ranking the evaluation criteria.
   [PA156.IG101.SP103.SubP102]

   Scales of relative importance for evaluation criteria can be established with non-numeric values or with formulas that relate the evaluation parameter to a numerical weight. [PA156.IG101.SP103.SubP102.N101]

3. Rank the criteria. [PA156.IG101.SP103.SubP103]

   The criteria are ranked according to the defined range and scale to reflect the needs, objectives, and priorities of the relevant stakeholders.
   [PA156.IG101.SP103.SubP103.N101]

4. Assess the criteria and their relative importance. [PA156.IG101.SP103.SubP105]
5. Evolve the evaluation criteria to improve their validity.
   [PA156.IG101.SP103.SubP106]
6. Document the rationale for the selection and rejection of evaluation criteria. [PA156.IG101.SP103.SubP104]

   Documentation of selection criteria and rationale may be needed to justify solutions or for future reference and use. [PA156.IG101.SP103.SubP104.N101]

SP 1.3 Identify Alternative Solutions

Identify alternative solutions to address issues. *[PA156.IG101.SP104]*

A wider range of alternatives can surface by soliciting as many stakeholders as practical for input. Input from stakeholders with diverse skills and backgrounds can help teams identify and address assumptions, constraints, and biases. Brainstorming sessions may stimulate innovative alternatives through rapid interaction and feedback. Sufficient candidate solutions may not be furnished for analysis. As the analysis proceeds, other alternatives should be added to the list of potential candidate solutions. The generation and consideration of multiple alternatives early in a decision analysis and resolution process increases the likelihood that an acceptable decision will be made, and that consequences of the decision will be understood. [PA156.IG101.SP104.N101]

Typical Work Products

1. Identified alternatives [PA156.IG101.SP104.W101]

Subpractices

1. Perform a literature search. [PA156.IG101.SP104.SubP101]

   A literature search can uncover what others have done both inside and outside the organization. It may provide a deeper understanding of the problem, alternatives to consider, barriers to implementation, existing trade studies, and lessons learned from similar decisions. [PA156.IG101.SP104.SubP101.N101]

2. Identify alternatives for consideration in addition to those that may be provided with the issue. [PA156.IG101.SP104.SubP102]

   Evaluation criteria are an effective starting point for identifying alternatives. The evaluation criteria identify the priorities of the relevant stakeholders and the importance of technical challenges. [PA156.IG101.SP104.SubP102.N101]

   Combining key attributes of existing alternatives can generate additional and sometimes stronger alternatives. [PA156.IG101.SP104.SubP102.N102]

   Solicit alternatives from relevant stakeholders. Brainstorming sessions, interviews, and working groups can be used effectively to uncover alternatives. [PA156.IG101.SP104.SubP102.N103]

3. Document the proposed alternatives. [PA156.IG101.SP104.SubP103]

SP 1.4 Select Evaluation Methods

Select the evaluation methods. *[PA156.IG101.SP102]*

Methods for evaluating alternative solutions against established criteria can range from simulations to the use of probabilistic models and decision theory. These methods need to be carefully selected. The level of detail of a method should be commensurate with cost, schedule, performance, and risk impacts. [PA156.IG101.SP102.N101]

While many problems may need only one evaluation method, some problems may require multiple methods. For instance, simulations may augment a trade study to determine which design alternative best meets a given criterion. [PA156.IG101.SP102.N102]

Typical Work Products

1. Selected evaluation methods [PA156.IG101.SP102.W101]

Subpractices

1. Select the methods based on the purpose for analyzing a decision and on the availability of the information used to support the method. [PA156.IG101.SP102.SubP101]

   For example, the methods used for evaluating a technical solution when requirements are weakly defined may be different from the methods used when the requirements are well defined. [PA156.IG101.SP102.SubP101.N101]

   Typical evaluation methods include the following: [PA156.IG101.SP102.SubP101.N102]

   - Simulations
   - Engineering studies
   - Manufacturing studies
   - Cost studies
   - Business opportunity studies
   - Surveys
   - Extrapolations based on field experience and prototypes
   - User review and comment
   - Testing

2. Select evaluation methods based on their ability to focus on the issues at hand without being overly influenced by side issues. [PA156.IG101.SP102.SubP102]

   Results of simulations can be skewed by random activities in the solution that are not directly related to the issues at hand. [PA156.IG101.SP102.SubP102.N101]

3. Determine the measures needed to support the evaluation method. [PA156.IG101.SP102.SubP103]

   Consider the impact on cost, schedule, performance, and risks. [PA156.IG101.SP102.SubP103.N101]

SP 1.5 Evaluate Alternatives

Evaluate alternative solutions using the established criteria and methods. *[PA156.IG101.SP105]*

Evaluating alternative solutions involves analysis, discussion, and review. Iterative cycles of analysis are sometimes necessary. Supporting analyses, experimentation, prototyping, or simulations may be needed to substantiate scoring and conclusions. [PA156.IG101.SP105.N101]

Often, the relative importance of criteria is imprecise and the total effect on a solution is not apparent until after the analysis is performed. In cases where the resulting scores differ by relatively small amounts, the best selection among alternative solutions may not be clearcut. Challenges to criteria and assumptions should be encouraged. [PA156.IG101.SP105.N102]

Typical Work Products

1. Evaluation results [PA156.IG101.SP105.W101]

Subpractices

1. Evaluate the proposed alternative solutions using the established evaluation criteria and selected methods. [PA156.IG101.SP105.SubP101]

2. Evaluate the assumptions related to the evaluation criteria and the evidence that supports the assumptions. [PA156.IG101.SP105.SubP102]

3. Evaluate whether uncertainty in the values for alternative solutions affects the evaluation and address as appropriate. [PA156.IG101.SP105.SubP103]

   For instance, if the score can vary between two values, is the difference significant enough to make a difference in the final solution set? Does the variation in score represent a high risk? To address these concerns, simulations may be run, further studies may be performed, or evaluation criteria may be modified, among other things. [PA156.IG101.SP105.SubP103.N101]

4. Perform simulations, modeling, prototypes, and pilots as necessary to exercise the evaluation criteria, methods, and alternative solutions. [PA156.IG101.SP105.SubP104]

   Untested criteria, their relative importance, and supporting data or functions may cause the validity of solutions to be questioned. Criteria and their relative priorities and scales can be tested with trial runs against a set of alternatives. These trial runs of a select set of criteria allow for the evaluation of the cumulative impact of the criteria on a solution. If the trials reveal problems, different criteria or alternatives might be considered to avoid biases. [PA156.IG101.SP105.SubP104.N101]

5. Consider new alternative solutions, criteria, or methods if the proposed alternatives do not test well; repeat the evaluations until alternatives do test well. [PA156.IG101.SP105.SubP105]

6. Document the results of the evaluation. [PA156.IG101.SP105.SubP106]

Document the rationale for the addition of new alternatives or methods and changes to criteria, as well as the results of interim evaluations.
[PA156.IG101.SP105.SubP106.N101]

SP 1.6 Select Solutions

Select solutions from the alternatives based on the evaluation criteria. *[PA156.IG101.SP106]*

Selecting solutions involves weighing the results from the evaluation of alternatives. Risks associated with implementation of the solutions must be assessed. [PA156.IG101.SP106.N101]

Typical Work Products

1. Recommended solutions to address significant issues
[PA156.IG101.SP106.W101]

Subpractices

1. Assess the risks associated with implementing the recommended solution. [PA156.IG101.SP106.SubP101]

   Refer to the Risk Management process area for more information about identifying and managing risks. *[PA156.IG101.SP106.SubP101.R101]*

   Decisions must often be made with incomplete information. There can be substantial risk associated with the decision because of having incomplete information. [PA156.IG101.SP106.SubP101.N101]

   When decisions must be made according to a specific schedule, time and resources may not be available for gathering complete information. Consequently, risky decisions made with incomplete information may require re-analysis later. Identified risks should be monitored. [PA156.IG101.SP106.SubP101.N102]

2. Document the results and rationale for the recommended solution.
[PA156.IG101.SP106.SubP102]

   It is important to record both why a solution is selected and why another solution was rejected. [PA156.IG101.SP106.SubP102.N101]

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the decision analysis and resolution process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for selectively analyzing possible decisions using a formal evaluation process that evaluates identified alternatives against established criteria. The policy should also provide guidance on which decisions require a formal evaluation process. [PA156.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined decision analysis and resolution process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the decision analysis and resolution process. *[GP104]*

Elaboration:

Typically, this plan for performing the decision analysis and resolution process is included in (or is referenced by) the project plan, which is described in the Project Planning process area. [PA156.EL110]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the decision analysis and resolution process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Examples of resources provided include the following tools: [PA156.EL102]

- Simulators and modeling tools
- Prototyping tools
- Tools for conducting surveys

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the decision analysis and resolution process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the decision analysis and resolution process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA156.EL103]

- Formal decision analysis
- Methods for evaluating alternative solutions against criteria

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the decision analysis and resolution process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA156.EL104]

- Guidelines for when to apply a formal evaluation process
- Evaluation reports containing recommended solutions

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the decision analysis and resolution process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include the following: [PA156.EL109]

- Establishing guidelines for which issues are subject to a formal evaluation process
- Establishing evaluation criteria
- Identifying and evaluating alternatives
- Selecting evaluation methods
- Selecting solutions

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the decision analysis and resolution process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA156.EL105]

- Cost-to-benefit ratio of using formal evaluation processes

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the decision analysis and resolution process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the decision analysis and resolution process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA156.EL106]

- Evaluating alternatives using established criteria and methods

Examples of work products reviewed include the following: [PA156.EL108]

- Guidelines for when to apply a formal evaluation process
- Evaluation reports containing recommended solutions

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the decision analysis and resolution process with higher level management and resolve issues. *[GP112]*

ORGANIZATIONAL ENVIRONMENT FOR INTEGRATION

Maturity Level 3

Purpose

The purpose of Organizational Environment for Integration is to provide an Integrated Product and Process Development (IPPD) infrastructure and manage people for integration. [PA169]

Introductory Notes

Successful integration of business and technical elements in projects is dependent upon substantive and proactive organizational processes and guidelines. The organization is an integrated system capable of providing and sustaining the people, products, and processes necessary for the effective and efficient execution of its projects. The organization must raise performance expectations from all projects while providing mechanisms that stimulate both team and individual excellence. [PA169.N101]

Important characteristics of effective environments for integration include people trained to exploit the collaborative environment; a workplace that provides resources to maximize the productivity of people and facilitate integrated teams; and organization's set of standard processes and organizational process assets that culturally enable an IPPD environment that promotes and rewards team as well as individual excellence. [PA169.N102]

Related Process Areas

Refer to the Integrated Project Management for IPPD process area for more information about managing relevant stakeholder involvement, resolving coordination issues, establishing the shared vision of a project, and organizing integrated teams. [PA169.R104]

Refer to the Organizational Process Definition process area for more information about establishing the organization's set of standard processes and process asset library. [PA169.R102]

Refer to the Organizational Training process area for more information about identifying training needs and providing the necessary training. [PA169.R103]

Specific and Generic Goals

SG 1 **Provide IPPD Infrastructure** [PA169.IG101]

An infrastructure that maximizes the productivity of people and affects the collaboration necessary for integration is provided.

SG 2 **Manage People for Integration** [PA169.IG102]

People are managed to nurture the integrative and collaborative behaviors of an IPPD environment.

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Provide IPPD Infrastructure [PA169.IG101]

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Specific Practices by Goal

SG 1 Provide IPPD Infrastructure

An infrastructure that maximizes the productivity of people and affects the collaboration necessary for integration is provided. *[PA169.IG101]*

An organizational infrastructure that supports and promotes IPPD concepts is critical if IPPD is to be successfully sustained over the long term. An IPPD infrastructure includes the following: [PA169.IG101.N101]

- An organization's shared vision that promotes IPPD concepts such as concurrent development and integrated teaming
- A work environment that enables efficient and effective collaboration and integration
- People trained to collaborate, integrate, and lead others, as necessary

SP 1.1 Establish the Organization's Shared Vision

Establish and maintain a shared vision for the organization.

[PA169.IG101.SP101]

Establishing and maintaining the organization's shared vision involves creating, communicating, using, and periodically evaluating and revising the shared vision. An organization's shared vision captures the organization's guiding principles including mission, objectives, expected behavior, and values. The shared visions of a project's integrated teams should be consistent with the project's shared vision, which in turn should be consistent with the organization's shared vision. See the definition of "shared vision" in Chapter 3 for an explanation of how this term is used in the CMMI Product Suite. [PA169.IG101.SP101.N101]

Creating a shared vision involves establishing and actively maintaining agreement and commitment about what is to be done and how it will be accomplished, both procedurally and behaviorally. A shared vision is a result of an ongoing dialogue among all the people who will make it real. It continues to evolve as more ideas are shared. [PA169.IG101.SP101.N102]

The organization's shared vision facilitates people working together, helps those people to attain unity of purpose, and creates a common understanding of the end state the organization is aiming to achieve. The organization's shared vision must speak to every element of the organization. Effectively impacting the lowest levels of the organization necessitates impacting the highest levels as well. The organization's leaders need to be role models for the actions of the organization. Their commitment to IPPD is critical to its success in the organization. They must clearly communicate their expectations for the organization's projects and integrated teams and what the projects and integrated teams can expect from the management. [PA169.IG101.SP101.N103]

The organization's shared vision needs to be grounded in reality. Organizations may be tempted to include in their shared vision broad statements about integrated teaming and employee empowerment. It is more important, however, to use the shared vision to set reasonable expectations on the rate of change in an organization. Unrealistic proclamations can transform the shared vision into a source of frustration and cause the organization to retreat from it after initial pilot demonstrations. [PA169.IG101.SP101.N104]

The organization's shared vision should be articulated in sufficient detail to provide criteria against which the shared visions of the projects and integrated teams can be aligned. For example, the organization's shared vision should address the use of integrated teams for projects, the focus on the customer, and the concurrent development of both product-related life-cycle processes and the product. These concepts should in turn be reflected in the shared visions of the projects and integrated teams. Guidelines for how projects and integrated teams should develop their shared visions should be made part of the organization's process asset library. [PA169.IG101.SP101.N105]

Maintenance of the organization's shared vision involves evaluating its use and currency. Results of evaluations may indicate the need to update the organization's shared vision or to establish and maintain organizational practices and structures that implement the shared vision. [PA169.IG101.SP101.N106]

Typical Work Products

1. Organization's shared vision [PA169.IG101.SP101.W101]
2. Evaluations of the organization's shared vision [PA169.IG101.SP101.W102]
3. Guidelines for shared-vision building within projects and integrated teams [PA169.IG101.SP101.W103]

Subpractices

1. Identify expectations, constraints, interfaces, and boundary conditions applicable to the organization's shared vision.
   [PA169.IG101.SP101.SubP101]

2. Create a shared vision for the organization. [PA169.IG101.SP101.SubP102]

   The shared vision can include what the people in the organization can expect from the organization (for example, some organizations have developed an "employee's bill of rights"). [PA169.IG101.SP101.SubP102.N101]

3. Communicate the shared vision both externally and internally. [PA169.IG101.SP101.SubP103]

4. Ensure that organizational practices and structures are aligned with the shared vision. [PA169.IG101.SP101.SubP104]

5. Periodically review the shared vision and update it as necessary. [PA169.IG101.SP101.SubP105]

   Reexamine the shared vision to determine weaknesses and misunderstood parts. Revise the shared vision to improve its clarity and applicability to the current state of the organization. Periodically reinforce the clarity and reality of the shared vision. [PA169.IG101.SP101.SubP105.N101]

6. Provide guidelines for shared-vision building for use by projects and integrated teams. [PA169.IG101.SP101.SubP106]

   These guidelines should establish the context for the shared visions of the projects and integrated teams. [PA169.IG101.SP101.SubP106.N101]

   Shared visions of the projects should be focused on product and contribute to achievement of the organization's shared vision. Shared visions of the projects could relate the minimum competencies, or demonstrated capabilities, for people assigned to integrated teams, such as individual leadership capabilities. Proposed products, activities, partnerships, organizational and project structures, and shared visions of the projects are tested against the organization's shared vision. [PA169.IG101.SP101.SubP106.N102]

   For the integrated teams, nurturing integration necessitates special attention to the objectives, values, and behaviors that are needed to affect integrated teamwork. Aspects such as team operations, team behaviors, team responsibilities, and collaboration with interfacing teams can be addressed. [PA169.IG101.SP101.SubP106.N103]

SP 1.2 Establish an Integrated Work Environment

Establish and maintain an integrated work environment that supports IPPD by enabling collaboration and concurrent development. *[PA169.IG101.SP102]*

An integrated work environment includes the physical infrastructure (e.g., facilities, tools, equipment, and support needed to effectively use them) that people need to perform their jobs effectively. Properly functioning environments help people communicate clearly and efficiently about the product, processes, people needs, and organization. An integrated work environment helps integrate the business and technical functions and the interfaces among teams, projects, and organizations. [PA169.IG101.SP102.N101]

The integrated work environment must accommodate both collocated and distributed integrated teams as required. Two-way communications media should be easily accessible by all relevant stakeholders. [PA169.IG101.SP102.N102]

Encouraging open dialogue by providing communication mechanisms enables everyone to effectively engage in and contribute to information sharing. Appropriate mechanisms might include meeting rooms, email, fax, FTP or Web sites, video teleconferencing capabilities, and others depending on the organization's culture and its project and integrated team preferences for efficient and effective information sharing. The types of information needed, which agents (projects, integrated teams, or individuals), and how many of them produce, own, and need that information should be considered in deciding the mechanisms to be used. [PA169.IG101.SP102.N103]

Integrated communication tool sets reduce time spent converting information from one medium or platform to another, and correcting transcriptions or misunderstandings when people do the conversions. Requirements for product and process information usability throughout the life of the product are important characteristics to consider in the selection of information-exchange tools. In an IPPD environment, it is particularly important that the tools for designing and developing the product-related life-cycle processes are integrated with the tools for designing and developing the product and product components. [PA169.IG101.SP102.N104]

Integrated work environments are developed with the same, or greater, rigor as that used to develop a specific product or service. Integrated work environments are capital assets that are often expensive, have unique implementations, are irreversible (their implementation can destroy or make unusable the assets being replaced), and whose modification disrupts ongoing activities. The rigor appropriate to the development should be matched to the magnitude of the needs to be resolved and the deployment risks. [PA169.IG101.SP102.N105]

Typical Work Products

1. Requirements for the integrated work environment [PA169.IG101.SP102.W101]
2. Design of the integrated work environment [PA169.IG101.SP102.W102]

3. Integrated work environment [PA169.IG101.SP102.W103]

Subpractices

1. Determine requirements for the integrated work environment. [PA169.IG101.SP102.SubP101]

   Requirements for the integrated work environment are typically based on the following: [PA169.IG101.SP102.SubP101.N101]

   - The organization's set of standard processes
   - The objectives of the organization articulated in the organization's shared vision
   - The needs associated with developing, maintaining, and delivering the products and services of the organization

2. Regularly evaluate the effectiveness of the existing environment and forecast the need for additional, upgraded, or new tools or integrated work environment components. [PA169.IG101.SP102.SubP102]

3. Maintain awareness of current and emerging technologies, tools, and resources that are related to the integrated work environment. [PA169.IG101.SP102.SubP103]

   Maintaining awareness may be accomplished through industry journals, professional societies, conferences, trade shows, or benchmarking. [PA169.IG101.SP102.SubP103.N101]

Examples of technologies, tools, and resources include the following:
[PA169.IG101.SP102.SubP103.N102]

- Computing resources and software productivity tools
- Communications systems, tools, and resources
- Communication tools (email, telephone, databases, archives, etc.)
- Manufacturing and production facilities
- Engineering or simulation tools
- Proprietary engineering tools
- Prototyping or production equipment
- Work space
- Office equipment and supplies
- Raw or stock input materials
- Transportation resources
- "Hotlines" and "help desks"
- Information brokerage services
- Support staff and/or services
- Information-technology capabilities
- Process enactment and management tools

4. Plan, design, and implement an integrated work environment.
[PA169.IG101.SP102.SubP104]

The critical aspects of the work environment are, like any other system, requirements driven. Work environment functionality (stimulated by customer needs and requirements) is explored with the same rigor as any other system development. Are the performance improvements (for example, timely interoperable communications, safety, security, maintainability) worth the costs (for example, capital outlays, training, support structure, disassembly and disposal of existing environments, performance and maintenance of the environment) and risks (for example, work flow and project disruptions)? Requirements are developed for the duration of the work environment and address, as appropriate, the three different cases for work environment improvements: developing a new environment, migrating an existing environment to new capabilities, and maintaining awareness of new and evolving technologies to exploit improvement opportunities. As required, the integrated work environment or some of its components can be developed in house or acquired from external sources.
[PA169.IG101.SP102.SubP104.N101]

5. Provide ongoing maintenance and operational support for the integrated work environment. [PA169.IG101.SP102.SubP105]

Maintenance and support of the integrated work environment can be accomplished either with capabilities found inside the organization or hired from outside the organization. [PA169.IG101.SP102.SubP105.N101]

Examples of maintenance and support methods include the following: [PA169.IG101.SP102.SubP105.N102]

- Hiring people to perform the maintenance and support
- Training people to perform the maintenance and support
- Contracting the maintenance and support
- Developing expert users for selected automation tools

6. Monitor and evaluate the adequacy of the integrated work environment to satisfy user needs. [PA169.IG101.SP102.SubP106]

Refer to the Project Monitoring and Control process area for more information about practices for monitoring and controlling the work environment. *[PA169.IG101.SP102.SubP106.R101]*

The work environment should be monitored throughout its existence to ascertain if, and when, its performance degrades below that expected (or specified) as well as to identify opportunities for improvements. The key operating characteristics of the integrated work environment should be identified. The key operating characteristics are those performance, product, and process characteristics that can be measured and compared against expected capabilities of the integrated work environment. End users should be surveyed to determine the adequacy of the current environment and to identify potential improvements. Changes should be planned and implemented based on the analysis of usage and performance data and on identified real and potential problems. [PA169.IG101.SP102.SubP106.N101]

7. Revise the integrated work environment as necessary, by adding, deleting, or replacing components. [PA169.IG101.SP102.SubP107]

SP 1.3 Identify IPPD-Unique Skill Requirements

Identify the unique skills needed to support the IPPD environment. *[PA169.IG101.SP103]*

Refer to the Organizational Training process area for more information about determining training needs and delivering the training.

[PA169.IG101.SP103.R101]

IPPD is a sufficiently different view of product development that the organization's leadership and work force will need to develop new skills. IPPD requires integrative leadership, and interpersonal skills beyond those typically found in traditional environments where people tend to work alone or primarily interact with others from their own, or similar, functions, or disciplines. Specific skills emphasized in an IPPD environment include the following: [PA169.IG101.SP103.N101]

- The skills to integrate all appropriate business and technical functions and their processes
- The interpersonal skills to coordinate and collaborate with others
- The leadership skills to act, and successfully influence others to act, to achieve the shared vision

Training to support these new skills must be established and maintained to sustain the ongoing adoption of IPPD in the organization. [PA169.IG101.SP103.N102]

Each integrated team member needs to understand what is vital to other team members in terms of product characteristics and the descriptions, expectations, and interfaces of the processes associated with the other functions represented on the team. This understanding can often be augmented through cross training of individuals across their function or discipline boundaries. [PA169.IG101.SP103.N103]

Collaboration among integrated team members is essential to create a team product rather than a collection of independent products. Enhanced interpersonal skills can help bridge the differences between disparate functions and disciplines as well as the differences in cultures, values, and backgrounds. [PA169.IG101.SP103.N104]

Leadership demands also increase under IPPD. Leadership challenges include: ensuring that all team members mutually understand their roles and responsibilities; employing people in their intended roles; and effectively accessing the depth and wealth of specific expertise resident in the organization and integrating it into the overall integrated team effort. [PA169.IG101.SP103.N105]

Typical Work Products

1. IPPD strategic training needs [PA169.IG101.SP103.W101]
2. IPPD tactical training needs [PA169.IG101.SP103.W102]

Subpractices

1. Provide requirements for IPPD skills for inclusion in the organization's strategic training needs. [PA169.IG101.SP103.SubP101]
2. Provide requirements for IPPD skills for inclusion in the organization's tactical training plan. [PA169.IG101.SP103.SubP102]

SG 2 Manage People for Integration

People are managed to nurture the integrative and collaborative behaviors of an IPPD environment. *[PA169.IG102]*

In an IPPD environment, special attention needs to be paid to aspects of organizational leadership and management. Nurturing integration necessitates focus on the objectives, values, and behaviors that are needed to affect integrated teamwork. The organization establishes the IPPD guidelines and processes that become part of the organization's set of standard processes and the project's defined process. The organization's standard processes enable, promote, and reinforce the integrative behaviors expected from projects, integrated teams, and people. For all IPPD processes and guidelines, people are recognized not as the tools or means to the end, but as part of a mutually beneficial collaboration to achieve the objectives. [PA169.IG102.N101]

In stimulating the integration needed, team-related incentives may be appropriate for people who work together. However, the value of individual excellence should not be overlooked. A balanced approach that addresses both individual performance as well as team performance would help maintain high standards of both team and individual achievement. Expectations from projects, integrated teams, and people are typically communicated in the form of policies, operating procedures, guidelines, and other organizational process assets. [PA169.IG102.N102]

SP 2.1 Establish Leadership Mechanisms

Establish and maintain leadership mechanisms to enable timely collaboration. *[PA169.IG102.SP101]*

Implementing IPPD introduces challenges to leadership because of the cultural changes required when people and integrated teams are empowered and decisions are driven to the lowest level appropriate. Effective and efficient communication mechanisms are critical to timely and sound decision making in the integrated work environment. Once an integrated work environment is established and training is provided, mechanisms to handle empowerment, decision making, and issue resolution also need to be provided to affect the timely collaboration of relevant stakeholders required for IPPD. [PA169.IG102.SP101.N101]

In an IPPD environment, it is particularly important that clear channels of responsibility and authority be established. Within the projects and the organization, issues can arise when individuals or integrated teams assume too much or too little authority and when the level at which decisions are made, or who owns what decisions, is unclear. Organizational guidelines that scope the degree of empowerment for integrated teams serve an issue-prevention role. Best practices promote documented and deployed organizational guidelines that can preclude issues arising from empowerment and authority misinterpretation. [PA169.IG102.SP101.N102]

Empowerment does not necessarily mean that every decision in an IPPD environment must occur at the lowest level, that it must be done collaboratively, or even that it must reflect consensus among all integrated team members or project participants. Decisions on the style and procedures for leadership and decision making for projects and among integrated teams need to be made in collaboration with the relevant stakeholders. In establishing the context for decision making, the various kinds of issues are described and agreements are reached on the decision type that will be used to resolve each kind of issue. [PA169.IG102.SP101.N103]

Some examples of decision types include the following: [PA169.IG102.SP101.N104]

- Command. The leader examines the issue and makes a decision alone.
- Consultative. The leader receives and examines inputs on the issue from relevant stakeholders and makes the decision.
- Collaborative. Issues are raised by any relevant stakeholders (including the leader), the issues are discussed, and the solutions are voted upon. Rules are needed to determine whether this vote is binding on the leader.
- Consensus. Issues are raised by any relevant stakeholders, including the leader, and are discussed until all members of the integrated team can live with and support the decision.
- Structured. Major issues may be decided using formal evaluations. The steps in formal evaluations may be carried out in a collaborative way.

For many issues, a command decision may be adequate. For issues that require several different areas of expertise or that have far-reaching consequences, collaborative decisions may be more appropriate. Defining decision types and the authority of those entrusted to make decisions enables efficient operations. [PA169.IG102.SP101.N105]

Mechanisms that grow leadership talent enable lower organizational unit delegation, which, in turn, enables faster, better responses to changing customer needs, technology, and environmental conditions. [PA169.IG102.SP101.N106]

Leadership characteristics cannot be viewed as solely embodied in the manager/leader. When leadership characteristics are evident in more than the leader, individual group members lead decision making and activities that heavily involve their areas of expertise. This flexibility can result in improved group efficiency and effectiveness. [PA169.IG102.SP101.N107]

Even with well-intentioned empowerment, leadership, and decision making, issues will arise that cannot be resolved at the same level. An organizational process for issue resolution can form the basis for project- and integrated-team-specific procedures and help ensure that basic issue-resolution avenues are available to projects and integrated teams when unresolved issues must be escalated. An organizational process for issue resolution can serve both issue-resolution and issue-prevention roles. [PA169.IG102.SP101.N108]

Typical Work Products

1. Guidelines for determining the degree of empowerment of people and integrated teams [PA169.IG102.SP101.W101]
2. Guidelines for setting leadership and decision-making context [PA169.IG102.SP101.W102]
3. Organizational process documentation for issue resolution [PA169.IG102.SP101.W103]

Subpractices

1. Establish and maintain guidelines for the degree of empowerment provided to people and integrated teams. [PA169.IG102.SP101.SubP101]
2. Collaboratively determine rules for the use of different decision types in making various kinds of decisions. [PA169.IG102.SP101.SubP102]

   Refer to the Decision Analysis and Resolution process area for more information about approaches for evaluating and selecting among alternatives. *[PA169.IG102.SP101.SubP102.R101]*
3. Define the process for using the decision-making rules. [PA169.IG102.SP101.SubP103]
4. Define a process for conflict resolution when an issue cannot be decided at the level at which it arose. [PA169.IG102.SP101.SubP104]

SP 2.2 Establish Incentives for Integration

Establish and maintain incentives for adopting and demonstrating integrative and collaborative behaviors at all levels of the organization. *[PA169.IG102.SP102]*

The recognition and reward systems in an organization are one of the motivators for behavior and value changes. To support IPPD, the recognition and reward systems (both positive rewards and negative consequences) need to recognize a shift in values from a single point of success or failure (e.g., providing a management incentive package to the product or program manager alone) to integrated team success or failure (e.g., providing layered incentives to integrated team members based on degree of involvement and contribution). [PA169.IG102.SP102.N101]

Individual excellence still should be recognized, but criteria should discern whether such excellence was achieved at the expense of the integrative behaviors expected or in support of them. For example, individuals (such as leaders) removing integration barriers or implementing collaboration capabilities may be just as important as an integrated team performing well. Care should be taken, however, not to single out individuals for recognition for a team's achievement. [PA169.IG102.SP102.N102]

Incentives should be consistent with the objectives of the organization and applied to achieve desired behavior at all levels of the organization. Criteria can establish guidelines for the reassignment of people who are unable to demonstrate desired behavior and the selection of people who can exhibit desired behavior for challenging or important jobs. [PA169.IG102.SP102.N103]

Compensation is not the only motivator, although giving an object of some value is an appropriate recognition. Reinforcement of positive behavior via thanks or praise is usually appropriate, especially soon after the observed performance of a task. Such immediate recognition reinforces the collaborative nature of working in an IPPD environment. If staff must wait for yearly performance appraisals, their motivation for working outside of their strict functional job description is lessened. [PA169.IG102.SP102.N104]

The yearly performance appraisals also need to be addressed. Review mechanisms should be structured so that both home organization supervisors and team leaders contribute to a person's performance review. [PA169.IG102.SP102.N105]

Typical Work Products

1. Policies and procedures for performance appraisal and recognition that reinforce collaboration [PA169.IG102.SP102.W101]
2. Integrated team and individual recognition and rewards [PA169.IG102.SP102.W102]

Subpractices

1. Structure the recognition and reward system to be consistent with the IPPD environment. [PA169.IG102.SP102.SubP101]

   The organization's recognition and reward system should recognize the value of individual and integrated team excellence and enable, promote, and reinforce integration. [PA169.IG102.SP102.SubP101.N101]

2. Develop guidelines for team as well as individual recognition. [PA169.IG102.SP102.SubP102]

3. Define procedures for integrated review processes that involve both the integrated team leader and the functional manager. [PA169.IG102.SP102.SubP103]

4. Establish criteria for distinguishing behaviors that promote integrated team performance from those that establish barriers to team behaviors. [PA169.IG102.SP102.SubP104]

SP 2.3 Establish Mechanisms to Balance Team and Home Organization Responsibilities

Establish and maintain organizational guidelines to balance team and home organization responsibilities. *[PA169.IG102.SP103]*

Here "home organization" refers to that part of the organization to which personnel are assigned when they are not in an integrated team. This home organization may be called the "functional organization," "home base," "home office," or "direct organization." Regardless of what it is called, it is often responsible for the career growth of the personnel assigned to it (e.g., performance appraisals and training to maintain functional and discipline expertise). In an IPPD environment, reporting procedures and rating systems should recognize that people's responsibility is focused on the integrated team, not on the traditional home organization. A balance must be struck, however, because the responsibility of integrated team members to their respective home organizations is still important, specifically for process implementation and improvement. Workloads should be balanced between projects and functions, while ensuring career growth and advancement. Mechanisms should be created that support the home organization responsibility but align the work force to meet business objectives in a teaming environment. [PA169.IG102.SP103.N101]

Striking this balance is difficult for an organization but exceedingly important for the personnel and the success of IPPD implementation. The balance must be reflected in the personal or career development plans for each individual. The knowledge and skills needed for an individual to succeed in both their functional and integrated team role should be honed, taking into account current and future assignments. [PA169.IG102.SP103.N102]

Guidelines should also be in place for disbanding teams and maintaining home organizations. It has been observed that sometimes teams attempt to remain in place beyond their productive life in organizations that do not have a home organization for the team members to report back to after the team is dissolved. [PA169.IG102.SP103.N103]

Typical Work Products

1. Organizational guidelines for balancing team and home organization responsibilities [PA169.IG102.SP103.W101]

2. Performance review process that considers both functional supervisor and team leader input [PA169.IG102.SP103.W102]

Subpractices

1. Establish guidelines for home organization responsibilities in promoting integrated team behavior. [PA169.IG102.SP103.SubP101]
2. Establish guidelines for team management responsibilities to ensure integrated team members report appropriately to their home organization. [PA169.IG102.SP103.SubP102]
3. Establish a performance review process that considers input from home organization and integrated team leaders. [PA169.IG102.SP103.SubP103]

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the organizational environment for integration process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for providing an IPPD infrastructure and managing people for integration. [PA169.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined organizational environment for integration process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the organizational environment for integration process. *[GP104]*

Elaboration:

This plan for performing the organizational environment for integration process may be included in or referenced by the project plan, which is described in the Project Planning process area, or it may be documented in a separate plan that describes only the plan for the organizational environment for integration process. [PA169.EL111]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the organizational environment for integration process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Examples of special equipment and facilities include the following: [PA169.EL103]

- Manufacturing and production facilities
- Prototyping or production equipment
- Work space
- Office equipment and supplies
- Raw or stock input materials
- Transportation resources
- "Hotlines" and "help desks"
- Information brokerage services
- Support staff and/or services

Examples of other resources provided include the following tools: [PA169.EL104]

- Communications systems, tools, and resources
- Computing resources and software productivity tools
- Engineering or simulation tools
- Proprietary engineering tools
- Information-technology capabilities

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the organizational environment for integration process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the organizational environment for integration process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA169.EL105]

- Work environment development
- Ergonomics
- Leadership policies for IPPD
- Managing people for integration and collaboration

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the organizational environment for integration process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA169.EL106]

- Organizational guidelines that determine the degree of empowerment of individuals and integrated teams
- Organizational process documentation for issue resolution
- Organization's shared vision

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the organizational environment for integration process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include the following: [PA169.EL107]

- Establishing and maintaining the organization's shared vision
- Establishing and maintaining the integrated work environment
- Establishing IPPD skill needs
- Establishing and maintaining IPPD leadership mechanisms
- Establishing and maintaining organizational policies for the management of people in an IPPD environment

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the organizational environment for integration process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA169.EL108]

- Parameters for key operating characteristics of the work environment

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the organizational environment for integration process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational environment for integration process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA169.EL109]

- Establishing the shared vision for the organization
- Developing guidelines for the degree of empowerment provided to people and teams
- Establishing and maintaining an issue-resolution process

Examples of work products reviewed include the following: [PA169.EL110]

- Organization's shared vision
- Organizational guidelines that determine the degree of empowerment of individuals and integrated teams
- Organizational process documentation for issue resolution
- Compensation policies and procedures

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the organizational environment for integration process with higher level management and resolve issues. *[GP112]*

MATURITY LEVEL 4: QUANTITATIVELY MANAGED

The following section contains all of the process areas that belong to maturity level 4. The maturity level 4 process areas of CMMI are as follows: [FM111.T101]

- Organizational Process Performance
- Quantitative Project Management

See Chapter 2 for more information about CMMI maturity levels. [FM111.T103]

ORGANIZATIONAL PROCESS PERFORMANCE

Maturity Level 4

Purpose

The purpose of Organizational Process Performance is to establish and maintain a quantitative understanding of the performance of the organization's set of standard processes in support of quality and process-performance objectives, and to provide the process performance data, baselines, and models to quantitatively manage the organization's projects. [PA164]

Introductory Notes

Process performance is a measure of the actual results achieved by following a process. Process performance is characterized by both process measures (e.g., effort, cycle time, and defect removal effectiveness) and product measures (e.g., reliability and defect density). [PA164.N101]

The common measures for the organization are composed of process and product measures that can be used to summarize the actual performance of processes in individual projects in the organization. The organizational data for these measures are analyzed to establish a distribution and range of results, which characterize the expected performance of the process when used on any individual project in the organization. [PA164.N102]

In this process area, the phrase "quality and process-performance objectives" covers objectives and requirements for product quality, service quality, and process performance. As indicated above, the term "process performance" includes product quality; however, to emphasize the importance of product quality, the phrase "quality and process-performance objectives" is used rather than just "process-performance objectives." [PA164.N106]

The expected process performance can be used in establishing the project's quality and process-performance objectives and can be used as a baseline against which actual project performance can be compared. This information is used to quantitatively manage the project. Each quantitatively managed project, in turn, provides actual performance results that become a part of the baseline data for the organizational process assets. [PA164.N103]

The associated process performance models are used to represent past and current process performance and to predict future results of the process. For example, the latent defects in the delivered product can be predicted using measurements of defects identified during the product verification activities. [PA164.N104]

When the organization has measures, data, and analytic techniques for critical process and product characteristics, it is able to do the following: [PA164.N105]

- Determine whether processes are behaving consistently or have stable trends (i.e., are predictable)
- Identify processes where the performance is within natural bounds that are consistent across process implementation teams
- Establish criteria for identifying whether a process or process element should be statistically managed, and determine pertinent measures and analytic techniques to be used in such management
- Identify processes that show unusual (e.g., sporadic or unpredictable) behavior
- Identify any aspects of the processes that can be improved in the organization's set of standard processes
- Identify the implementation of a process which performs best

Related Process Areas

Refer to the Quantitative Project Management process area for more information about the use of process performance baselines and models. [PA164.R101]

Refer to the Measurement and Analysis process area for more information about specifying measures and collecting and analyzing data. [PA164.R102]

Specific and Generic Goals

SG 1 Establish Performance Baselines and Models [PA164.IG101]

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

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Establish Performance Baselines and Models [PA164.IG101]

SP 1.1		Select Processes
SP 1.2		Establish Process Performance Measures
SP 1.3		Establish Quality and Process-Performance Objectives
SP 1.4		Establish Process Performance Baselines
SP 1.5		Establish Process Performance Models

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 3.1	(AB 1)	Establish a Defined Process
GP 2.2	(AB 2)	Plan the Process
GP 2.3	(AB 3)	Provide Resources
GP 2.4	(AB 4)	Assign Responsibility
GP 2.5	(AB 5)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 3.2	(DI 4)	Collect Improvement Information
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

Specific Practices by Goal

SG 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. *[PA164.IG101]*

Prior to establishing process performance baselines and models, it is necessary to determine which processes are suitable to be measured (the Select Processes specific practice), which measures are useful for determining process performance (the Establish Process Performance Measures specific practice), and the quality and process-performance objectives for those processes (the Establish Quality and Process-Performance Objectives specific practice). These specific practices are often interrelated and may need to be performed concurrently to select the appropriate processes, measures, and quality and process-performance objectives. Often, the selection of one process, measure, or objective will constrain the selection of the others. For example, if a certain process is selected, the measures and objectives for that process may be constrained by the process itself. [PA164.IG101.N101]

SP 1.1 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. *[PA164.IG101.SP101]*

Refer to the Organizational Process Definition process area for more information about the structure of the organizational process assets.
[PA164.IG101.SP101.R101]

The organization's set of standard processes consists of a set of standard processes that, in turn, are composed of process elements.
[PA164.IG101.SP101.N101]

Typically, it will not be possible, useful, or economically justifiable to apply statistical management techniques to all processes or process elements of the organization's set of standard processes. Selection of the processes and/or process elements is based upon the needs and objectives of both the organization and projects. [PA164.IG101.SP101.N102]

Typical Work Products

1. List of processes or process elements identified for process performance analyses [PA164.IG101.SP101.W101]

SP 1.2 Establish Process Performance Measures

Establish and maintain definitions of the measures that are to be included in the organization's process performance analyses.
[PA164.IG101.SP102]

Refer to the Measurement and Analysis process area for more information about selecting measures. *[PA164.IG101.SP102.R101]*

Typical Work Products

1. Definitions for the selected measures of process performance
[PA164.IG101.SP102.W101]

Subpractices

1. Determine which of the organization's business objectives for quality and process performance need to be addressed by the measures. [PA164.IG101.SP102.SubP101]

2. Select measures that provide appropriate insight into the organization's quality and process performance. [PA164.IG101.SP102.SubP102]

   The Goal Question Metric paradigm is an approach that can be used to select measures that provide insight into the organization's business objectives.
   [PA164.IG101.SP102.SubP102.N101]

Examples of criteria used to select measures include the following: [PA164.IG101.SP102.SubP102.N102]

- Relationship of the measures to the organization's business objectives
- Coverage that the measures provide over the entire life of the product
- Visibility that the measures provide into the process performance
- Availability of the measures
- Extent to which the measures are objective
- Frequency at which the observations of the measure can be collected
- Extent to which the measures are controllable by changes to the process
- Extent to which the measures represent the users' view of effective process performance

3. Incorporate the selected measures into the organization's set of common measures. [PA164.IG101.SP102.SubP103]

   Refer to the Organizational Process Definition process area for more information about establishing organizational process assets. *[PA164.IG101.SP102.SubP103.R101]*

4. Revise the set of measures as necessary. [PA164.IG101.SP102.SubP104]

SP 1.3 Establish Quality and Process-Performance Objectives

Establish and maintain quantitative objectives for quality and process performance for the organization. *[PA164.IG101.SP103]*

The organization's quality and process-performance objectives should have the following attributes: [PA164.IG101.SP103.N101]

- Based on the organization's business objectives
- Based on the past performance of projects
- Defined to gauge process performance in areas such as product quality, productivity, or cycle time
- Constrained by the inherent variability or natural bounds of the process

Typical Work Products

1. Organization's quality and process-performance objectives [PA164.IG101.SP103.W101]

Subpractices

1. Review the organization's business objectives related to quality and process performance. [PA164.IG101.SP103.SubP101]

Examples of business objectives include the following: [PA164.IG101.SP103.SubP101.N101]

- Achieve a development cycle of a specified duration for a specified release of a product
- Decrease the cost of maintenance of the products by a specified percent

2. Define the organization's quantitative objectives for quality and process performance. [PA164.IG101.SP103.SubP102]

   Objectives may be established for both process measurements (e.g., effort, cycle time, and defect removal effectiveness) and product measurements (e.g., reliability and defect density). [PA164.IG101.SP103.SubP102.N101]

Examples of quality and process-performance objectives include the following: [PA164.IG101.SP103.SubP102.N102]

- Achieve a specified productivity
- Deliver work products with no more than a specified number of latent defects

3. Define the priorities of the organization's objectives for quality and process performance. [PA164.IG101.SP103.SubP103]
4. Review, negotiate, and obtain commitment for the organization's quality and process-performance objectives and their priorities from the relevant stakeholders. [PA164.IG101.SP103.SubP104]
5. Revise the organization's quantitative objectives for quality and process performance as necessary. [PA164.IG101.SP103.SubP105]

Examples of when the organization's quantitative objectives for quality and process performance may need to be revised include the following: [PA164.IG101.SP103.SubP105.N101]

- When the organization's business objectives change
- When the organization's processes change
- When actual quality and process performance differs significantly from the objectives

SP 1.4 Establish Process Performance Baselines

Establish and maintain the organization's process performance baselines. *[PA164.IG101.SP104]*

The organization's process performance baselines are a measurement of performance for the organization's set of standard processes at various levels of detail, as appropriate. The processes include the following: [PA164.IG101.SP104.N101]

- Individual process elements (e.g., test-case inspection element)

- Sequence of connected processes
- Processes that cover the entire life of the project
- Processes for developing individual work products

There may be several process performance baselines to characterize performance for subgroups of the organization. [PA164.IG101.SP104.N102]

Examples of criteria used to categorize subgroups include the following: [PA164.IG101.SP104.N104]

- Product line
- Application domain
- Complexity
- Team size
- Work product size
- Process elements from the organization's set of standard processes

Allowable tailoring of the organization's set of standard processes may significantly affect the comparability of the data for inclusion in process performance baselines. The effects of tailoring should be considered in establishing baselines. [PA164.IG101.SP104.N103]

Refer to the Quantitative Project Management process area for more information about the use of process performance baselines.
[PA164.IG101.SP104.N103.R101]

Typical Work Products

1. Baseline data on the organization's process performance
   [PA164.IG101.SP104.W101]

Subpractices

1. Collect measurements from the organization's projects.
   [PA164.IG101.SP104.SubP101]

   The process in use when the measurement was taken is recorded to enable appropriate use at a later date. [PA164.IG101.SP104.SubP101.N101]

   Refer to the Measurement and Analysis process area for information about collecting and analyzing data.
   [PA164.IG101.SP104.SubP101.N101.R101]

2. Establish and maintain the organization's process performance baselines from the collected measurements and analyses.
   [PA164.IG101.SP104.SubP102]

Refer to the Measurement and Analysis process area for information about establishing objectives for measurement and analysis, specifying the measures and analyses to be performed, obtaining and analyzing measures, and reporting results.
[PA164.IG101.SP104.SubP102.R101]

Process performance baselines are derived by analyzing the collected measures to establish a distribution and range of results that characterize the expected performance for selected processes when used on any individual project in the organization. [PA164.IG101.SP104.SubP102.N102]

The measurements from stable processes from projects should be used; other data may not be reliable. [PA164.IG101.SP104.SubP102.N101]

3. Review and get agreement with relevant stakeholders about the organization's process performance baselines. [PA164.IG101.SP104.SubP103]

4. Make the organization's process performance information available across the organization in the organization's measurement repository. [PA164.IG101.SP104.SubP104]

   The organization's process performance baselines are used by the projects to estimate the natural bounds for process performance. [PA164.IG101.SP104.SubP104.N101]

   Refer to the Organizational Process Definition process area for more information about establishing the organization's measurement repository. *[PA164.IG101.SP104.SubP104.N101.R101]*

5. Compare the organization's process performance baselines to the associated objectives. [PA164.IG101.SP104.SubP105]

6. Revise the organization's process performance baselines as necessary. [PA164.IG101.SP104.SubP106]

   Examples of when the organization's process performance baselines may need to be revised include the following: [PA164.IG101.SP104.SubP106.N101]

   - When the processes change
   - When the organization's results change
   - When the organization's needs change

SP 1.5 Establish Process Performance Models

Establish and maintain the process performance models for the organization's set of standard processes. *[PA164.IG101.SP105]*

Process performance models are used to estimate or predict the value of a process performance measure from the values of other process and product measurements. These process performance models typically use process and product measurements collected throughout the life of the project to estimate progress toward achieving objectives that cannot be measured until later in the project's life. [PA164.IG101.SP105.N101]

The process performance models are used as follows: [PA164.IG101.SP105.N102]

- The organization uses them for estimating, analyzing, and predicting the process performance associated with the processes in the organization's set of standard processes.
- The organization uses them to assess the (potential) return on investment for process-improvement activities.
- Projects use them for estimating, analyzing, and predicting the process performance for their defined processes.
- Projects use them for selecting processes for use.

These measures and models are defined to provide insight into and to provide the ability to predict critical process and product characteristics that are relevant to business value. [PA164.IG101.SP105.N103]

Examples of areas of concern to projects in which models may be useful include the following: [PA164.IG101.SP105.N104]

- Schedule and cost
- Reliability
- Defect identification and removal rates
- Defect removal effectiveness
- Latent defect estimation
- Project progress
- Combinations of these areas

Examples of process performance models include the following: [PA164.IG101.SP105.N105]

- System dynamics models
- Reliability growth models
- Complexity models

Refer to the Quantitative Project Management process area for more information about the use of process performance models.

[PA164.IG101.SP105.N105.R101]

Typical Work Products

1. Process performance models [PA164.IG101.SP105.W101]

Subpractices

1. Establish the process performance models based on the organization's set of standard processes and the organization's process performance baselines. [PA164.IG101.SP105.SubP101]
2. Calibrate the process performance models based on the organization's past results and current needs. [PA164.IG101.SP105.SubP102]
3. Review the process performance models and get agreement with relevant stakeholders. [PA164.IG101.SP105.SubP103]
4. Support the projects' use of the process performance models. [PA164.IG101.SP105.SubP104]
5. Revise the process performance models as necessary. [PA164.IG101.SP105.SubP105]

Examples of when the process performance models may need to be revised include the following: [PA164.IG101.SP105.SubP105.N101]

- When the processes change
- When the organization's results change
- When the organization's needs change

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the organizational process performance process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for establishing and maintaining process performance baselines for the organization's set of standard processes. [PA164.EL101]

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined organizational process performance process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the organizational process performance process. *[GP104]*

Elaboration:

This plan for performing the organizational process performance process may be included in or referenced by the organization's process-improvement plan, which is described in the Organizational Process Focus process area, or it may be documented in a separate plan that describes only the plan for the organizational process performance process. [PA164.EL113]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the organizational process performance process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Special expertise in statistics and statistical process control may be needed to establish the process performance baselines for the organization's set of standard processes. [PA164.EL111]

Examples of other resources provided include the following tools: [PA164.EL102]

- Database management systems
- System dynamic models
- Process modeling tools
- Statistical analysis packages
- Problem-tracking packages

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the organizational process performance process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the organizational process performance process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA164.EL103]

- Process and process-improvement modeling
- Quantitative and statistical methods (e.g., estimating models, Pareto analysis, and control charts)

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the organizational process performance process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA164.EL104]

- Organization's quality and process-performance objectives
- Definition for the selected measures of process performance
- Baseline data on the organization's process performance

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the organizational process performance process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include the following: [PA164.EL112]

- Establishing the organization's quality and process-performance objectives and their priorities
- Reviewing and resolving issues on the organization's process performance baselines
- Reviewing and resolving issues on the organization's process performance models

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the organizational process performance process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA164.EL105]

- Trends in the organization's process performance with respect to changes in work products and task attributes (e.g., size growth, effort, schedule, and quality)

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the organizational process performance process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational process performance process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA164.EL106]

- Establishing process performance baselines and models

Examples of work products reviewed include the following: [PA164.EL110]

- Process performance plans
- Organization's quality and process-performance objectives
- Definition for the selected measures of process performance

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the organizational process performance process with higher level management and resolve issues. *[GP112]*

QUANTITATIVE PROJECT MANAGEMENT

Maturity Level 4

Purpose

The purpose of the Quantitative Project Management process area is to quantitatively manage the project's defined process to achieve the project's established quality and process-performance objectives. [PA165]

Introductory Notes

The Quantitative Project Management process area involves the following: [PA165.N101]

- Establishing and maintaining the project's quality and process-performance objectives
- Identifying suitable subprocesses that compose the project's defined process based on historical stability and capability data found in process performance baselines or models
- Selecting the subprocesses of the project's defined process to be statistically managed
- Monitoring the project to determine whether the project's objectives for quality and process performance are being satisfied, and identifying appropriate corrective action
- Selecting the measures and analytic techniques to be used in statistically managing the selected subprocesses
- Establishing and maintaining an understanding of the variation of the selected subprocesses using the selected measures and analytic techniques
- Monitoring the performance of the selected subprocesses to determine whether they are capable of satisfying their quality and process-performance objectives, and identifying corrective action
- Recording statistical and quality management data in the organization's measurement repository

The quality and process-performance objectives, measures, and baselines identified above are developed as described in the Organizational Process Performance process area. Subsequently, the results of performing the processes associated with the Quantitative Project Management process area (e.g., measurement definitions and measurement data) become part of the organizational process assets referred to in the Organizational Process Performance process area. [PA165.N102]

To effectively address the specific practices in this process area, the organization should have already established a set of standard processes and related organizational process assets, such as the organization's measurement repository and the organization's process asset library, for use by each project in establishing its defined process. The project's defined process is a set of subprocesses that form an integrated and coherent life cycle for the project. It is established, in part, through selecting and tailoring processes from the organization's set of standard processes. See Chapter 3 for an explanation of how "defined process" is used in the CMMI Product Suite. [PA165.N103]

Process performance is a measure of the actual process results achieved. Process performance 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). [PA165.N106]

Subprocesses are defined components of a larger defined process. For example, a typical organization's development process may be defined in terms of subprocesses such as requirements development, design, build, test, and peer review. The subprocesses themselves may be further decomposed as necessary into other subprocesses and process elements. [PA165.N107]

One essential element of quantitative management is having confidence in estimates (i.e., being able to predict the extent to which the project can fulfill its quality and process-performance objectives). The subprocesses that will be statistically managed are chosen based on identified needs for predictable performance. See the definitions of "statistically managed process" and "quantitatively managed process" in Appendix C, the glossary. See Chapter 3 for an explanation of how "quality and process-performance objective" is used in the CMMI Product Suite. [PA165.N108]

Another essential element of quantitative management is understanding the nature and extent of the variation experienced in process performance, and recognizing when the project's actual performance may not be adequate to achieve the project's quality and process-performance objectives. [PA165.N109]

Statistical management involves statistical thinking and the correct use of a variety of statistical techniques, such as run charts, control charts, confidence intervals, prediction intervals, and tests of hypotheses. Quantitative management uses data from statistical management to help the project predict whether it will be able to achieve its quality and process-performance objectives and identify what corrective action should be taken. [PA165.N110]

This process area applies to managing a project, but the concepts found here also apply to managing other groups and functions. Applying these concepts to managing other groups and functions may not necessarily contribute to achieving the organization's business objectives, but may help these groups and functions control their own processes. [PA165.N111]

Examples of other groups and functions include the following: [PA165.N113]

- Quality assurance
- Process definition and improvement
- Effort reporting
- Customer complaint handling
- Problem tracking and reporting

Related Process Areas

Refer to the Project Monitoring and Control process area for more information about monitoring and controlling the project and taking corrective action. [PA165.R101]

Refer to the Measurement and Analysis process area for more information about establishing measurable objectives, specifying the measures and analyses to be performed, obtaining and analyzing measures, and providing results. [PA165.R102]

Refer to the Organizational Process Performance process area for more information about the organization's quality and process-performance objectives, process performance analyses, process performance baselines, and process performance models. [PA165.R103]

Refer to the Organizational Process Definition process area for more information about the organizational process assets, including the organization's measurement repository. [PA165.R104]

Refer to the Integrated Project Management process area for more information about establishing and maintaining the project's defined process. [PA165.R105]

Refer to the Causal Analysis and Resolution process area for more information about how to identify the causes of defects and other problems, and taking action to prevent them from occurring in the future. [PA165.R106]

Refer to the Organizational Innovation and Deployment process area for more information about selecting and deploying improvements that support the organization's quality and process-performance objectives. [PA165.R107]

Specific and Generic Goals

SG 1 **Quantitatively Manage the Project** [PA165.IG101]

The project is quantitatively managed using quality and process-performance objectives.

SG 2 **Statistically Manage Subprocess Performance** [PA165.IG102]

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

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Quantitatively Manage the Project [PA165.IG101]

SP 1.1	Establish the Project's Objectives
SP 1.2	Compose the Defined Process
SP 1.3	Select the Subprocesses that Will Be Statistically Managed
SP 1.4	Manage Project Performance

SG 2 Statistically Manage Subprocess Performance [PA165.IG102]

SP 2.1	Select Measures and Analytic Techniques
SP 2.2	Apply Statistical Methods to Understand Variation
SP 2.3	Monitor Performance of the Selected Subprocesses
SP 2.4	Record Statistical Management Data

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 3.1	(AB 1)	Establish a Defined Process
GP 2.2	(AB 2)	Plan the Process
GP 2.3	(AB 3)	Provide Resources
GP 2.4	(AB 4)	Assign Responsibility
GP 2.5	(AB 5)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders

GP 2.8	(DI 3)	Monitor and Control the Process
GP 3.2	(DI 4)	Collect Improvement Information
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

Specific Practices by Goal

SG 1 Quantitatively Manage the Project

The project is quantitatively managed using quality and process-performance objectives. *[PA165.IG101]*

SP 1.1 Establish the Project's Objectives

Establish and maintain the project's quality and process-performance objectives. *[PA165.IG101.SP101]*

When establishing the project's quality and process-performance objectives, it is often useful to think ahead about which processes from the organization's set of standard processes will be included in the project's defined process, and what the historical data indicates regarding their process performance. These considerations will help in establishing realistic objectives for the project. Later, as the project's actual performance becomes known and more predictable, the objectives may need to be revised. [PA165.IG101.SP101.N102]

Typical Work Products

1. The project's quality and process-performance objectives
   [PA165.IG101.SP101.W101]

Subpractices

1. Review the organization's objectives for quality and process performance. [PA165.IG101.SP101.SubP101]

   The intent of this review is to ensure that the project understands the broader business context in which the project will need to operate. The project's objectives for quality and process performance are developed in the context of these overarching organizational objectives. [PA165.IG101.SP101.SubP101.N101]

   Refer to the Organizational Process Performance process area for more information about the organization's quality and process-performance objectives. *[PA165.IG101.SP101.SubP101.N101.R101]*

2. Identify the quality and process performance needs and priorities of the customer, end users, and other relevant stakeholders.
   [PA165.IG101.SP101.SubP102]

Examples of quality and process performance attributes for which needs and priorities might be identified include the following: [PA165.IG101.SP101.SubP102.N101]

- Functionality
- Reliability
- Maintainability
- Usability
- Duration
- Predictability
- Timeliness
- Accuracy

3. Identify how process performance is to be measured. [PA165.IG101.SP101.SubP103]

   Consider whether the measures established by the organization are adequate for assessing progress in fulfilling customer, end-user, and other stakeholder needs and priorities. It may be necessary to supplement these with additional measures. [PA165.IG101.SP101.SubP103.N101]

   Refer to the Measurement and Analysis process area for more information about defining measures. *[PA165.IG101.SP101.SubP103.N101.R101]*

4. Define and document measurable quality and process-performance objectives for the project. [PA165.IG101.SP101.SubP104]

   Defining and documenting objectives for the project involve the following: [PA165.IG101.SP101.SubP104.N101]

   - Incorporating the organization's quality and process-performance objectives
   - Writing objectives that reflect the quality and process-performance needs and priorities of the customer, end users, and other stakeholders, and the way these objectives should be measured

Examples of quality attributes for which objectives might be written include the following: [PA165.IG101.SP101.SubP104.N102]

- Mean time between failures
- Critical resource utilization
- Number and severity of defects in the released product
- Number and severity of customer complaints concerning the provided service

Examples of process performance attributes for which objectives might be written include the following: [PA165.IG101.SP101.SubP104.N103]

- Percentage of defects removed by product verification activities (perhaps by type of verification, such as peer reviews and testing)
- Defect escape rates
- Number and density of defects (by severity) found during the first year following product delivery (or start of service)
- Cycle time
- Percentage of rework time

5. Derive interim objectives for each life-cycle phase, as appropriate, to monitor progress toward achieving the project's objectives. [PA165.IG101.SP101.SubP105]

An example of a method to predict future results of a process is the use of process performance models to predict the latent defects in the delivered product using interim measures of defects identified during product verification activities (e.g., peer reviews and testing). [PA165.IG101.SP101.SubP105.N101]

6. Resolve conflicts among the project's quality and process-performance objectives (e.g., if one objective cannot be achieved without compromising another objective). [PA165.IG101.SP101.SubP106]

Resolving conflicts involves the following: [PA165.IG101.SP101.SubP106.N101]

- Setting relative priorities for the objectives
- Considering alternative objectives in light of long-term business strategies as well as short-term needs
- Involving the customer, end users, senior management, project management, and other relevant stakeholders in the tradeoff decisions
- Revising the objectives as necessary to reflect the results of the conflict resolution

7. Establish traceability to the project's quality and process-performance objectives from their sources. [PA165.IG101.SP101.SubP107]

Examples of sources for objectives include the following: [PA165.IG101.SP101.SubP107.N101]

- Requirements
- Organization's quality and process-performance objectives
- Customer's quality and process-performance objectives
- Business objectives
- Discussions with customers and potential customers
- Market surveys

An example of a method to identify and trace these needs and priorities is Quality Function Deployment (QFD). [PA165.IG101.SP101.SubP107.N102]

8. Define and negotiate quality and process-performance objectives for suppliers. [PA165.IG101.SP101.SubP108]

   Refer to the Supplier Agreement Management process area for more information about establishing and maintaining agreements with suppliers. *[PA165.IG101.SP101.SubP108.R101]*

9. Revise the project's quality and process-performance objectives as necessary. [PA165.IG101.SP101.SubP109]

SP 1.2 Compose the Defined Process

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

[PA165.IG101.SP102]

Refer to the Integrated Project Management process area for more information about establishing and maintaining the project's defined process. *[PA165.IG101.SP102.R101]*

Refer to the Organizational Process Definition process area for more information about the organization's process asset library, which might include a process element of known and needed capability.

[PA165.IG101.SP102.R102]

Refer to the Organizational Process Performance process area for more information about the organization's process performance baselines and process performance models. *[PA165.IG101.SP102.R103]*

Subprocesses are identified from the process elements in the organization's set of standard processes and the process artifacts in the organization's process asset library. [PA165.IG101.SP102.N101]

Typical Work Products

1. Criteria used in identifying which subprocesses are valid candidates for inclusion in the project's defined process [PA165.IG101.SP102.W101]
2. Candidate subprocesses for inclusion in the project's defined process [PA165.IG101.SP102.W102]
3. Subprocesses to be included in the project's defined process [PA165.IG101.SP102.W103]
4. Identified risks when selected subprocesses lack a process performance history [PA165.IG101.SP102.W104]

Subpractices

1. Establish the criteria to use in identifying which subprocesses are valid candidates for use. [PA165.IG101.SP102.SubP101]

   Identification may be based on the following: [PA165.IG101.SP102.SubP101.N101]

   - Quality and process-performance objectives
   - Existence of process-performance data
   - Product line standards
   - Project life-cycle models
   - Customer requirements
   - Laws and regulations

2. Determine whether the subprocesses that are to be statistically managed, and that were obtained from the organizational process assets, are suitable for statistical management. [PA165.IG101.SP102.SubP102]

   A subprocess may be more suitable for statistical management if it has a history of the following: [PA165.IG101.SP102.SubP102.N101]

   - Stable performance in previous comparable instances
   - Process performance data that satisfies the project's quality and process-performance objectives

   Historical data are primarily obtained from the organization's process performance baselines. However, these data may not be available for all subprocesses. [PA165.IG101.SP102.SubP102.N102]

3. Analyze the interaction of subprocesses to understand the relationships among the subprocesses and the measured attributes of the subprocesses. [PA165.IG101.SP102.SubP103]

Examples of analysis techniques include system dynamics models and simulations. [PA165.IG101.SP102.SubP103.N101]

4. Identify the risk when no subprocess is available that is known to be capable of satisfying the quality and process-performance objectives (i.e., no capable subprocess is available or the capability of the subprocess is not known). [PA165.IG101.SP102.SubP104]

   Even when a subprocess has not been selected to be statistically managed, historical data and process performance models may indicate that the subprocess is not capable of satisfying the quality and process-performance objectives. [PA165.IG101.SP102.SubP104.N101]

   Refer to the Risk Management process area for more information about risk identification and analysis. *[PA165.IG101.SP102.SubP104.N101.R101]*

SP 1.3 Select the Subprocesses that Will Be Statistically Managed

Select the subprocesses of the project's defined process that will be statistically managed. *[PA165.IG101.SP103]*

Selecting the subprocesses to be statistically managed is often a concurrent and iterative process of identifying applicable project and organization quality and process-performance objectives, selecting the subprocesses, and identifying the process and product attributes to measure and control. Often the selection of a process, quality and process-performance objective, or measurable attribute will constrain the selection of the other two. For example, if a particular process is selected, the measurable attributes and quality and process-performance objectives may be constrained by that process.

[PA165.IG101.SP103.N101]

Typical Work Products

1. Quality and process-performance objectives that will be addressed by statistical management [PA165.IG101.SP103.W101]
2. Criteria used in selecting which subprocesses will be statistically managed [PA165.IG101.SP103.W102]
3. Subprocesses that will be statistically managed [PA165.IG101.SP103.W103]
4. Identified process and product attributes of the selected subprocesses that should be measured and controlled [PA165.IG101.SP103.W104]

Subpractices

1. Identify which of the quality and process-performance objectives of the project will be statistically managed. [PA165.IG101.SP103.SubP101]
2. Identify the criteria to be used in selecting the subprocesses that are the main contributors to achieving the identified quality and process-performance objectives and for which predictable performance is important. [PA165.IG101.SP103.SubP102]

Examples of sources for criteria used in selecting subprocesses include the following: [PA165.IG101.SP103.SubP102.N102]

- Customer requirements related to quality and process performance
- Quality and process-performance objectives established by the customer
- Quality and process-performance objectives established by the organization
- Organization's performance baselines and models
- Stable performance of the subprocess on other projects
- Laws and regulations

3. Select the subprocesses that will be statistically managed using the selection criteria. [PA165.IG101.SP103.SubP104]

   It may not be possible to statistically manage some subprocesses (e.g., where new subprocesses and technologies are being piloted). In other cases, it may not be economically justifiable to apply statistical techniques to certain subprocesses. [PA165.IG101.SP103.SubP104.N101]

4. Identify the product and process attributes of the selected subprocesses that will be measured and controlled. [PA165.IG101.SP103.SubP103]

Examples of product and process attributes include the following: [PA165.IG101.SP103.SubP103.N101] • Defect density • Cycle time • Test coverage

SP 1.4 Manage Project Performance

Monitor the project to determine whether the project's objectives for quality and process performance will be satisfied, and identify corrective action as appropriate. *[PA165.IG101.SP104]*

Refer to the Measurement and Analysis process area for more information about analyzing and using measures. *[PA165.IG101.SP104.R101]*

A prerequisite for such a comparison is that the selected subprocesses of the project's defined process are being statistically managed and their process capability is understood. [PA165.IG101.SP104.N101]

Typical Work Products

1. Estimates (predictions) of the achievement of the project's quality and process-performance objectives [PA165.IG101.SP104.W101]
2. Documentation of the risks in achieving the project's quality and process-performance objectives [PA165.IG101.SP104.W102]
3. Documentation of actions needed to address the deficiencies in achieving the project's objectives [PA165.IG101.SP104.W103]

Subpractices

1. Periodically review the performance of each subprocess and the capability of each subprocess selected to be statistically managed, to appraise progress toward achieving the project's quality and process-performance objectives. [PA165.IG101.SP104.SubP101]

The process capability of each selected subprocess is determined with respect to that subprocess' established quality and process-performance objectives. These objectives are derived from the project's quality and process-performance objectives, which are for the project as a whole. [PA165.IG101.SP104.SubP101.N101]

2. Periodically review the actual results achieved against the established interim objectives for each phase of the project life cycle to appraise progress toward achieving the project's quality and process-performance objectives. [PA165.IG101.SP104.SubP102]

3. Track suppliers' results for achieving their quality and process-performance objectives. [PA165.IG101.SP104.SubP103]

4. Use process performance models calibrated with obtained measures of critical attributes to estimate progress toward achieving the project's quality and process-performance objectives. Process performance models are used to estimate progress toward achieving objectives that cannot be measured until a future phase in the project life cycle. An example is the use of process performance models to predict the latent defects in the delivered product using interim measures of defects identified during peer reviews. [PA165.IG101.SP104.SubP104]

   Refer to the Organizational Process Performance process area for more information about process performance models.
   [PA165.IG101.SP104.SubP104.R101]

   The calibration is based on the results obtained from performing the previous subpractices. [PA165.IG101.SP104.SubP104.N101]

5. Identify and manage the risks associated with achieving the project's quality and process-performance objectives.
   [PA165.IG101.SP104.SubP105]

   Refer to the Risk Management process area for more information about identifying and managing risks. *[PA165.IG101.SP104.SubP105.R101]*

   Example sources of the risks include the following: [PA165.IG101.SP104.SubP105.N101]

   - Inadequate stability and capability data in the organization's measurement repository
   - Subprocesses having inadequate performance or capability
   - Suppliers not achieving their quality and process-performance objectives
   - Lack of visibility into supplier capability
   - Inaccuracies in the organization's process performance models for predicting future performance
   - Deficiencies in predicted process performance (estimated progress)
   - Other identified risks associated with identified deficiencies

6. Determine and document actions needed to address the deficiencies in achieving the project's quality and process-performance objectives. [PA165.IG101.SP104.SubP106]

The intent of these actions is to plan and deploy the right set of activities, resources, and schedule to place the project back on track as much as possible to meet its objectives. [PA165.IG101.SP104.SubP106.N101]

Examples of actions that can be taken to address deficiencies in achieving the project's objectives include the following: [PA165.IG101.SP104.SubP106.N102]

- Changing quality or process performance objectives so that they are within the expected range of the project's defined process
- Improving the implementation of the project's defined process so as to reduce its normal variability (reducing variability may bring the project's performance within the objectives without having to move the mean)
- Adopting new subprocesses and technologies that have the potential for satisfying the objectives and managing the associated risks
- Identifying the risk and risk mitigation strategies for the deficiencies
- Terminating the project

Refer to the Project Monitoring and Control process area for more information about taking corrective action.

[PA165.IG101.SP104.SubP106.N102.R101]

SG 2 Statistically Manage Subprocess Performance

The performance of selected subprocesses within the project's defined process is statistically managed. *[PA165.IG102]*

This specific goal describes an activity critical to achieving the Quantitatively Manage the Project specific goal of this process area. The specific practices under this specific goal describe how to statistically manage the subprocesses whose selection was described in the specific practices under the first specific goal. When the selected subprocesses are statistically managed, their capability to achieve their objectives can be determined. By these means, it will be possible to predict whether the project will be able to achieve its objectives, which is key to quantitatively managing the project. [PA165.IG102.N101]

SP 2.1 Select Measures and Analytic Techniques

Select the measures and analytic techniques to be used in statistically managing the selected subprocesses. *[PA165.IG102.SP101]*

Refer to the Measurement and Analysis process area for more information about establishing measurable objectives; on defining, collecting, and analyzing measures; and on revising measures and statistical analysis techniques. [PA165.IG102.SP101.R101]

Typical Work Products

1. Definitions of the measures and analytic techniques to be used in (or proposed for) statistically managing the subprocesses [PA165.IG102.SP101.W101]
2. Operational definitions of the measures, their collection points in the subprocesses, and how the integrity of the measures will be determined [PA165.IG102.SP101.W102]
3. Traceability of measures back to the project's quality and process-performance objectives [PA165.IG102.SP101.W103]
4. Instrumented organizational support environment to support automatic data collection [PA165.IG102.SP101.W104]

Subpractices

1. Identify common measures from the organizational process assets that support statistical management. [PA165.IG102.SP101.SubP101]

   Refer to the Organizational Process Definition process area for more information about common measures. [PA165.IG102.SP101.SubP101.R101]

   Product lines or other stratification criteria may categorize common measures. [PA165.IG102.SP101.SubP101.N101]

2. Identify additional measures that may be needed for this instance to cover critical product and process attributes of the selected subprocesses. [PA165.IG102.SP101.SubP102]

   In some cases, measures may be research oriented. Such measures should be explicitly identified. [PA165.IG102.SP101.SubP102.N102]

3. Identify the measures that are appropriate for statistical management. [PA165.IG102.SP101.SubP103]

   Critical criteria for selecting statistical management measures include the following: [PA165.IG102.SP101.SubP103.N101]

   - Controllable (e.g., can a measure's values be changed by changing how the subprocess is implemented?)
   - Adequate performance indicator (e.g., is the measure a good indicator of how well the subprocess is performing relative to the objectives of interest?)

Examples of subprocess measures include the following: [PA165.IG102.SP101.SubP103.N102]

- Requirements volatility
- Ratios of estimated to measured values of the planning parameters (e.g., size, cost, and schedule)
- Coverage and efficiency of peer reviews
- Test coverage and efficiency
- Effectiveness of training (e.g., percent of planned training completed and test scores)
- Reliability
- Percentage of the total defects inserted or found in the different phases of the project life cycle
- Percentage of the total effort expended in the different phases of the project life cycle

4. Specify the operational definitions of the measures, their collection points in the subprocesses, and how the integrity of the measures will be determined. [PA165.IG102.SP101.SubP104]

   Operational definitions are stated in precise and unambiguous terms. They address two important criteria as follows: [PA165.IG102.SP101.SubP104.N101]

   - Communication: What has been measured, how it was measured, what the units of measure are, and what has been included or excluded
   - Repeatability: Whether the measurement can be repeated, given the same definition, to get the same results

5. Analyze the relationship of the identified measures to the organization's and project's objectives, and derive objectives that state specific target measures or ranges to be met for each measured attribute of each selected subprocess.
   [PA165.IG102.SP101.SubP105]

6. Instrument the organizational support environment to support collection, derivation, and analysis of statistical measures.
   [PA165.IG102.SP101.SubP106]

   The instrumentation is based on the following: [PA165.IG102.SP101.SubP106.N101]

   - Description of the organization's set of standard processes
   - Description of the project's defined process
   - Capabilities of the organizational support environment

7. Identify the appropriate statistical analysis techniques that are expected to be useful in statistically managing the selected subprocesses. [PA165.IG102.SP101.SubP107]

The concept of "one size does not fit all" applies to statistical analysis techniques. What makes a particular technique appropriate is not just the type of measures, but more importantly, how the measures will be used and whether the situation warrants applying that technique. The appropriateness of the selection may need to be investigated from time to time. [PA165.IG102.SP101.SubP107.N101]

Examples of statistical analysis techniques are given in the next specific practice. [PA165.IG102.SP101.SubP107.N102]

8. Revise the measures and statistical analysis techniques as necessary. [PA165.IG102.SP101.SubP108]

SP 2.2 Apply Statistical Methods to Understand Variation

Establish and maintain an understanding of the variation of the selected subprocesses using the selected measures and analytic techniques. *[PA165.IG102.SP102]*

Refer to the Measurement and Analysis process area for more information about collecting, analyzing, and using measure results. *[PA165.IG102.SP102.R101]*

Understanding variation is achieved, in part, by collecting and analyzing process and product measures so that special causes of variation can be identified and addressed to achieve predictable performance. [PA165.IG102.SP102.N101]

A special cause of process variation is characterized by an unexpected change in process performance. Special causes are also known as "assignable causes" because they can be identified, analyzed, and addressed to prevent recurrence. [PA165.IG102.SP102.N102]

The identification of special causes of variation is based on departures from the system of common causes of variation. These departures can be identified by the presence of extreme values, or other identifiable patterns in the data collected from the subprocess or associated work products. Knowledge of variation and insight about potential sources of anomalous patterns are typically needed to detect special causes of variation. [PA165.IG102.SP102.N103]

Sources of anomalous patterns of variation may include the following: [PA165.IG102.SP102.N104]

- Lack of process compliance
- Undistinguished influences of multiple underlying subprocesses on the data
- Ordering or timing of activities within the subprocess
- Uncontrolled inputs to the subprocess
- Environmental changes during subprocess execution
- Schedule pressure
- Inappropriate sampling or grouping of data

Typical Work Products

1. Collected measures [PA165.IG102.SP102.W101]
2. Natural bounds of process performance for each measured attribute of each selected subprocess [PA165.IG102.SP102.W102]
3. Process performance compared to the natural bounds of process performance for each measured attribute of each selected subprocess [PA165.IG102.SP102.W103]

Subpractices

1. Establish trial natural bounds for subprocesses having suitable historical performance data. [PA165.IG102.SP102.SubP101]

   Refer to the Organizational Process Performance process area for more information about organizational process performance baselines. *[PA165.IG102.SP102.SubP101.R101]*

   Natural bounds of an attribute are the range within which variation normally occurs. All processes will show some variation in process and product measures each time they are executed. The issue is whether this variation is due to common causes of variation in the normal performance of the process or to some special cause that can and should be identified and removed. [PA165.IG102.SP102.SubP101.N101]

   When a subprocess is initially executed, suitable data for establishing trial natural bounds are sometimes available from prior instances of the subprocess or comparable subprocesses, process performance baselines, or process performance models. These data are typically contained in the organization's measurement repository. As the subprocess is executed, data specific to that instance are collected and used to update and replace the trial natural bounds. However, if the subprocess in question has been materially tailored, or if the conditions are materially different than in previous instantiations, the data in the repository may not be relevant and should not be used. [PA165.IG102.SP102.SubP101.N102]

In some cases, there may be no historical comparable data (for example, when introducing a new subprocess, when entering a new application domain, or when significant changes have been made to the subprocess). In such cases, trial natural bounds will have to be made from early process data of this subprocess. These trial natural bounds must then be refined and updated as subprocess execution continues. [PA165.IG102.SP102.SubP101.N103]

Examples of criteria for determining whether data are comparable include the following: [PA165.IG102.SP102.SubP101.N104]

- Product lines
- Application domain
- Work product and task attributes (e.g., size of product)
- Size of project

2. Collect data, as defined by the selected measures, on the subprocesses as they execute. [PA165.IG102.SP102.SubP102]

3. Calculate the natural bounds of process performance for each measured attribute. [PA165.IG102.SP102.SubP103]

Examples of where the natural bounds are calculated include the following: [PA165.IG102.SP102.SubP103.N101]

- Control charts
- Confidence intervals (for parameters of distributions)
- Prediction intervals (for future outcomes)

4. Identify special causes of variation. [PA165.IG102.SP102.SubP104]

An example of a criterion for detecting a special cause of process variation in a control chart is a data point that falls outside of the 3-sigma control limits. [PA165.IG102.SP102.SubP104.N101]

The criteria for detecting special causes of variation are based on statistical theory and experience and depend on economic justification. As criteria are added, special causes are more likely to be identified if present, but the likelihood of false alarms also increases. [PA165.IG102.SP102.SubP104.N102]

5. Analyze the special cause of process variation to determine the reasons the anomaly occurred. [PA165.IG102.SP102.SubP105]

Examples of techniques for analyzing the reasons for special causes of variation include the following: [PA165.IG102.SP102.SubP105.N101]

- Cause-and-effect (fishbone) diagrams
- Designed experiments
- Control charts (applied to subprocess inputs or to lower level subprocesses)
- Subgrouping (analyzing the same data segregated into smaller groups based on an understanding of how the subprocess was implemented facilitates isolation of special causes)

Some anomalies may simply be extremes of the underlying distribution rather than problems. The people implementing a subprocess are usually the ones best able to analyze and understand special causes of variation. [PA165.IG102.SP102.SubP105.N102]

6. Determine what corrective action should be taken when special causes of variation are identified. [PA165.IG102.SP102.SubP106]

Removing a special cause of process variation does not change the underlying subprocess. It addresses an error in the way the subprocess is being executed. [PA165.IG102.SP102.SubP106.N101]

Refer to the Project Monitoring and Control process area for more information about taking corrective action.

[PA165.IG102.SP102.SubP106.N101.R101]

7. Recalculate the natural bounds for each measured attribute of the selected subprocesses as necessary. [PA165.IG102.SP102.SubP107]

Recalculating the (statistically estimated) natural bounds is based on measured values that signify that the subprocess has changed, not on expectations or arbitrary decisions. [PA165.IG102.SP102.SubP107.N101]

Examples of when the natural bounds may need to be recalculated include the following: [PA165.IG102.SP102.SubP107.N102]

- There are incremental improvements to the subprocess
- New tools are deployed for the subprocess
- A new subprocess is deployed
- The collected measures suggest that the subprocess mean has permanently shifted or the subprocess variation has permanently changed

SP 2.3 Monitor Performance of the Selected Subprocesses

Monitor the performance of the selected subprocesses to determine their capability to satisfy their quality and process-performance objectives, and identify corrective action as necessary. *[PA165.IG102.SP103]*

The intent of this specific practice is to do the following: [PA165.IG102.SP103.N101]

- Determine statistically the process behavior expected from the subprocess
- Appraise the probability that the process will meet its quality and process-performance objectives
- Identify the corrective action to be taken, based upon a statistical analysis of the process performance data

Corrective action may include renegotiating the affected project objectives, identifying and implementing alternative subprocesses, or identifying and measuring lower level subprocesses to achieve greater detail in the performance data. Any or all of these actions are intended to help the project use a more capable process. See the definition of "capable process" in Appendix C, the glossary. [PA165.IG102.SP103.N102]

A prerequisite for comparing the capability of a selected subprocess against its quality and process-performance objectives is that the performance of the subprocess is stable and predictable with respect to its measured attributes. [PA165.IG102.SP103.N104]

Process capability is analyzed for those subprocesses and those measured attributes for which (derived) objectives have been established. Not all subprocesses or measured attributes that are statistically managed are analyzed regarding process capability. [PA165.IG102.SP103.N105]

The historical data may be inadequate for initially determining whether the subprocess is capable. It also is possible that the estimated natural bounds for subprocess performance may shift away from the quality and process-performance objectives. In either case, statistical control implies monitoring capability as well as stability. [PA165.IG102.SP103.N106]

Typical Work Products

1. Natural bounds of process performance for each selected subprocess compared to its established (derived) objectives [PA165.IG102.SP103.W101]
2. For each subprocess, its process capability [PA165.IG102.SP103.W102]
3. For each subprocess, the actions needed to address deficiencies in its process capability [PA165.IG102.SP103.W103]

Subpractices

1. Compare the quality and process-performance objectives to the natural bounds of the measured attribute. [PA165.IG102.SP103.SubP101]

This comparison provides an appraisal of the process capability for each measured attribute of a subprocess. These comparisons can be displayed graphically, in ways that relate the estimated natural bounds to the objectives or as process capability indices, which summarize the relationship of the objectives to the natural bounds. [PA165.IG102.SP103.SubP101.N101]

2. Monitor changes in quality and process-performance objectives and selected subprocess' process capability. [PA165.IG102.SP103.SubP102]

3. Identify and document subprocess capability deficiencies. [PA165.IG102.SP103.SubP103]

4. Determine and document actions needed to address subprocess capability deficiencies. [PA165.IG102.SP103.SubP104]

Examples of actions that can be taken when a selected subprocess' performance does not satisfy its objectives include the following: [PA165.IG102.SP103.SubP104.N101]

- Changing quality and process-performance objectives so that they are within the subprocess' process capability
- Improving the implementation of the existing subprocess so as to reduce its normal variability (reducing variability may bring the natural bounds within the objectives without having to move the mean)
- Adopting new process elements and subprocesses and technologies that have the potential for satisfying the objectives and managing the associated risks
- Identifying risks and risk mitigation strategies for each subprocess' process capability deficiency

Refer to the Project Monitoring and Control process area for more information about taking corrective action.

[PA165.IG102.SP103.SubP104.N101.R101]

SP 2.4 Record Statistical Management Data

Record statistical and quality management data in the organization's measurement repository. *[PA165.IG102.SP104]*

Refer to the Measurement and Analysis process area for more information about managing and storing data, measurement definitions, and results. *[PA165.IG102.SP104.R101]*

Refer to the Organizational Process Definition process area for more information about the organization's measurement repository.

[PA165.IG102.SP104.R102]

Typical Work Products

1. Statistical and quality management data recorded in the organization's measurement repository [PA165.IG102.SP104.W101]

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the quantitative project management process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for quantitatively managing the project using quality and process-performance objectives, and statistically managing selected subprocesses within the project's defined process [PA165.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined quantitative project management process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the quantitative project management process. *[GP104]*

Elaboration:

Typically, this plan for performing the quantitative project management process is included in (or referenced by) the project plan, which is described in the Project Planning process area. [PA165.EL111]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the quantitative project management process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Special expertise in statistics and statistical process control may be needed to define the techniques for statistical management of selected subprocesses, but staff will use the tools and techniques to perform the statistical management. Special expertise in statistics may also be needed for analyzing and interpreting the measures resulting from statistical management. [PA165.EL102]

Examples of other resources provided include the following tools: [PA165.EL103]

- System dynamics models
- Automated test-coverage analyzers
- Statistical process and quality control packages
- Statistical analysis packages

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the quantitative project management process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the quantitative project management process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA165.EL104]

- Process modeling and analysis
- Process measurement data selection, definition, and collection

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the quantitative project management process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA165.EL110]

- Subprocesses to be included in the project's defined process
- Operational definitions of the measures, their collection points in the subprocesses, and how the integrity of the measures will be determined
- Collected measures

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the quantitative project management process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include the following: [PA165.EL109]

- Establishing project objectives
- Resolving issues among the project's quality and process-performance objectives
- Appraising performance of the selected subprocesses
- Identifying and managing the risks in achieving the project's quality and process-performance objectives
- Identifying what corrective action should be taken

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the quantitative project management process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA165.EL105]

- Profile of subprocesses under statistical management (e.g., number planned to be under statistical management, number currently being statistically managed, and number that are statistically stable)
- Number of special causes of variation identified

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the quantitative project management process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the quantitative project management process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA165.EL106]

- Quantitatively managing the project using quality and process-performance objectives
- Statistically managing selected subprocesses within the project's defined process

Examples of work products reviewed include the following: [PA165.EL108]

- Subprocesses to be included in the project's defined process
- Operational definitions of the measures
- Collected measures

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the quantitative project management process with higher level management and resolve issues. *[GP112]*

MATURITY LEVEL 5: OPTIMIZING

The following section contains all of the process areas that belong to maturity level 5. The maturity level 5 process areas of CMMI are as follows: [FM112.T101]

- Organizational Innovation and Deployment
- Causal Analysis and Resolution

See Chapter 2 for more information about CMMI maturity levels. [FM112.T102]

ORGANIZATIONAL INNOVATION AND DEPLOYMENT

Maturity Level 5

Purpose

The purpose of Organizational Innovation and Deployment is to select and deploy incremental and innovative improvements that measurably improve the organization's processes and technologies. The improvements support the organization's quality and process-performance objectives as derived from the organization's business objectives. [PA161]

Introductory Notes

The Organizational Innovation and Deployment process area enables the selection and deployment of improvements that can enhance the organization's ability to meet its quality and process-performance objectives. See Chapter 3 for an explanation of how "quality and process-performance objectives" is used in the CMMI Product Suite. The term "improvement," as used in this process area, refers to all ideas (proven and unproven) that would change the organization's processes and technologies to better meet the organization's quality and process-performance objectives. [PA161.N109]

Quality and process-performance objectives that this process area might address include the following: [PA161.N101]

- Improved product quality (e.g., functionality, performance)
- Increased productivity
- Decreased cycle time
- Greater customer and end-user satisfaction
- Shorter development or production time to change functionality, add features, or adapt to new technologies

Achievement of these objectives depends on the successful establishment of an infrastructure that enables and encourages all people in the organization to propose potential improvements to the organization's processes and technologies. Achievement of these objectives also depends on being able to effectively evaluate and deploy proposed improvements to the organization's processes and technologies. All members of the organization can participate in the organization's process- and technology-improvement activities. Their proposals are systematically gathered and addressed. [PA161.N102]

Pilots are conducted to evaluate significant changes involving untried, high-risk, or innovative improvements before they are broadly deployed. [PA161.N103]

Process and technology improvements that will be deployed across the organization are selected from process- and technology-improvement proposals based on the following criteria: [PA161.N104]

- A quantitative understanding of the organization's current quality and process performance
- The organization's quality and process-performance objectives
- Estimates of the improvement in quality and process performance resulting from deploying the process and technology improvements
- Estimated costs of deploying process and technology improvements, and the resources and funding available for such deployment

The expected benefits added by the process and technology improvements are weighed against the cost and impact to the organization. Change and stability must be balanced carefully. Change that is too great or too rapid can overwhelm the organization, destroying its investment in organizational learning represented by organizational process assets. Rigid stability can result in stagnation, allowing the changing business environment to erode the organization's business position. [PA161.N105]

Improvements are deployed, as appropriate, to new and ongoing projects. [PA161.N106]

In this process area, the term "process and technology improvements" refers to incremental and innovative improvements to processes and also to process or product technologies. [PA161.N107]

The informative material in this process area is written with the assumption that the specific practices are applied to a quantitatively managed process. The specific practices of this process area may be applicable, but with reduced value, if the assumption is not met. [PA161.N110]

The specific practices in this process area complement and extend those found in the Organizational Process Focus process area. The focus of this process area is process improvement that is based on a quantitative knowledge of the organization's set of standard processes and technologies and their expected quality and performance in predictable situations. In the Organizational Process Focus process area, no assumptions are made about the quantitative basis of improvement. [PA161.N108]

Related Process Areas

Refer to the Organizational Process Definition process area for more information about incorporating the deployed process improvements into organizational process assets. [PA161.R101]

Refer to the Organizational Process Focus process area for more information about soliciting, collecting, and handling process-improvement proposals and coordinating the deployment of process improvement into the project's defined processes. [PA161.R102]

Refer to the Organizational Training process area for more information about providing updated training to support deployment of process and technology improvements. [PA161.R103]

Refer to the Organizational Process Performance process area for more information about quality and process-performance objectives and process performance models. Quality and process-performance objectives are used to analyze and select process- and technology-improvement proposals for deployment. Process performance models are used to quantify the impact and benefits of innovations. [PA161.R104]

Refer to the Measurement and Analysis process area for more information about establishing objectives for measurement and analysis, specifying the measures and analyses to be performed, obtaining and analyzing measures, and reporting results. [PA161.R105]

Refer to the Integrated Project Management process area for more information about coordinating the deployment of process and technology improvements into the project's defined process. [PA161.R106]

Refer to the Decision Analysis and Resolution process area for more information about formal evaluations related to improvement proposals and innovations. [PA161.R108]

Specific and Generic Goals

SG 1 Select Improvements [PA161.IG101]

Process and technology improvements that contribute to meeting quality and process-performance objectives are selected.

SG 2 Deploy Improvements [PA161.IG102]

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

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Select Improvements [PA161.IG101]
- SP 1.1 Collect and Analyze Improvement Proposals
- SP 1.2 Identify and Analyze Innovations
- SP 1.3 Pilot Improvements
- SP 1.4 Select Improvements for Deployment

SG 2 Deploy Improvements [PA161.IG102]
- SP 2.1 Plan the Deployment
- SP 2.2 Manage the Deployment
- SP 2.3 Measure Improvement Effects

GG 3 Institutionalize a Defined Process [CL104.GL101]
- GP 2.1 (CO 1) Establish an Organizational Policy
- GP 3.1 (AB 1) Establish a Defined Process
- GP 2.2 (AB 2) Plan the Process
- GP 2.3 (AB 3) Provide Resources
- GP 2.4 (AB 4) Assign Responsibility
- GP 2.5 (AB 5) Train People
- GP 2.6 (DI 1) Manage Configurations
- GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders
- GP 2.8 (DI 3) Monitor and Control the Process
- GP 3.2 (DI 4) Collect Improvement Information
- GP 2.9 (VE 1) Objectively Evaluate Adherence
- GP 2.10 (VE 2) Review Status with Higher Level Management

Specific Practices by Goal

SG 1 Select Improvements

Process and technology improvements that contribute to meeting quality and process-performance objectives are selected. [PA161.IG101]

SP 1.1 Collect and Analyze Improvement Proposals

Collect and analyze process- and technology-improvement proposals. [PA161.IG101.SP101]

Each process- and technology-improvement proposal must be analyzed. [PA161.IG101.SP101.N101]

Simple process and technology improvements, with well-understood benefits and effects, will not usually undergo detailed evaluations. [PA161.IG101.SP101.N102]

Examples of simple process and technology improvements include the following: [PA161.IG101.SP101.N104]

- Add an item to a peer review checklist.
- Combine the technical review and management review for suppliers into a single technical/management review.

Typical Work Products

1. Analyzed process- and technology-improvement proposals [PA161.IG101.SP101.W101]

Subpractices

1. Collect process- and technology-improvement proposals. [PA161.IG101.SP101.SubP101]

   A process- and technology-improvement proposal documents proposed incremental and innovative improvements to specific processes and technologies. Managers and staff in the organization, as well as customers, end users, and suppliers can submit process- and technology-improvement proposals. Process and technology improvements may be implemented at the local level before being proposed for the organization. [PA161.IG101.SP101.SubP101.N101]

   Examples of sources for process- and technology-improvement proposals include the following: [PA161.IG101.SP101.SubP101.N102]

   - Findings and recommendations from process appraisals
   - The organization's quality and process-performance objectives
   - Analysis of data about customer and end-user problems as well as customer and end-user satisfaction
   - Analysis of data about project performance compared to quality and productivity objectives
   - Analysis of technical performance measures
   - Results of process and product benchmarking efforts
   - Analysis of data on defect causes
   - Measured effectiveness of process activities
   - Examples of process- and technology-improvement proposals that were successfully adopted elsewhere
   - Feedback on previously submitted process- and technology-improvement proposals
   - Spontaneous ideas from managers and staff

   Refer to the Organizational Process Focus process area for more information about process- and technology-improvement proposals. [PA161.IG101.SP101.SubP101.N102.R101]

2. Analyze the costs and benefits of process- and technology-improvement proposals as appropriate. [PA161.IG101.SP101.SubP102]

   Process- and technology-improvement proposals that have a large cost-to-benefit ratio are rejected. [PA161.IG101.SP101.SubP102.N101]

   Criteria for evaluating costs and benefits include the following:
   [PA161.IG101.SP101.SubP102.N102]

   - Contribution toward meeting the organization's quality and process-performance objectives
   - Effect on mitigating identified project and organizational risks
   - Ability to respond quickly to changes in project requirements, market situations, and the business environment
   - Effect on related processes and associated assets
   - Cost of defining and collecting data that supports the measurement and analysis of the process- and technology-improvement proposal
   - Expected life span of the proposal

   Process- and technology-improvement proposals that would not improve the organization's processes are rejected. [PA161.IG101.SP101.SubP102.N103]

   Process performance models provide insight into the effect of process changes on process capability and performance. [PA161.IG101.SP101.SubP102.N104]

   Refer to the Organizational Process Performance process area for more information about process performance models.
   [PA161.IG101.SP101.SubP102.N104.R101]

3. Identify the process- and technology-improvement proposals that are innovative. [PA161.IG101.SP101.SubP103]

   Innovative improvements are also identified and analyzed in the Identify and Analyze Innovations specific practice. [PA161.IG101.SP101.SubP103.N101]

   Whereas this specific practice analyzes proposals that have been passively collected, the purpose of the Identify and Analyze Innovations specific practice is to actively search for and locate innovative improvements. The search primarily involves looking outside the organization. [PA161.IG101.SP101.SubP103.N102]

   Innovative improvements are typically identified by reviewing process- and technology-improvement proposals or by actively investigating and monitoring innovations that are in use in other organizations or are documented in research literature. Innovation may be inspired by internal improvement objectives or by the external business environment. [PA161.IG101.SP101.SubP103.N103]

Innovative improvements are typically major changes to the process that represent a break from the old way of doing things (e.g., changing the life-cycle model). Innovative improvements may also include changes in the products that support, enhance, or automate the process (for example, using off-the-shelf products to support the process). [PA161.IG101.SP101.SubP103.N104]

Examples of innovative improvements include the following: [PA161.IG101.SP101.SubP103.N105]

- Advances in computer and related hardware products
- New support tools
- New techniques, methodologies, processes, or life-cycle models
- New interface standards
- New reusable components
- New management techniques
- New quality-improvement techniques
- New process-development and deployment-support tools

4. Identify potential barriers and risks to deploying each process- and technology-improvement proposal. [PA161.IG101.SP101.SubP104]

Examples of barriers to deploying process and technology improvements include the following: [PA161.IG101.SP101.SubP104.N101]

- Turf guarding and parochial perspectives
- Unclear or weak business rationale
- Lack of short-term benefits and visible successes
- Unclear picture of what is expected from everyone
- Too many changes at the same time
- Lack of involvement and support of relevant stakeholders

Examples of risk factors that affect the deployment of process and technology improvements include the following: [PA161.IG101.SP101.SubP104.N102]

- Compatibility of the improvement with existing processes, values, and skills of potential end users
- Complexity of the improvement
- Difficulty implementing the improvement
- Ability to demonstrate the value of the improvement before widespread deployment
- Justification for large, up-front investments in areas such as tools and training
- Inability to overcome "technology drag" where the current implementation is used successfully by a large and mature installed base of end users

5. Estimate the cost, effort, and schedule required for deploying each process- and technology-improvement proposal.
[PA161.IG101.SP101.SubP105]

6. Select the process- and technology-improvement proposals to be piloted before broadscale deployment. [PA161.IG101.SP101.SubP106]

   Since innovations, by definition, usually represent a major change, most innovative improvements will be piloted. [PA161.IG101.SP101.SubP106.N101]

7. Document the results of the evaluation of each process- and technology-improvement proposal. [PA161.IG101.SP101.SubP107]

8. Monitor the status of each process- and technology-improvement proposal. [PA161.IG101.SP101.SubP108]

SP 1.2 Identify and Analyze Innovations

Identify and analyze innovative improvements that could increase the organization's quality and process performance. *[PA161.IG101.SP102]*

The specific practice Collect and Analyze Improvement Proposals analyzed proposals that were passively collected. The purpose of this specific practice is to actively search for, locate, and analyze innovative improvements. This search primarily involves looking outside the organization. [PA161.IG101.SP102.N101]

Typical Work Products

1. Candidate innovative improvements [PA161.IG101.SP102.W101]
2. Analysis of proposed innovative improvements [PA161.IG101.SP102.W102]

Subpractices

1. Analyze the organization's set of standard processes to determine areas where innovative improvements would be most helpful.
[PA161.IG101.SP102.SubP101]

   These analyses are performed to determine which subprocesses are critical to achieving the organization's quality and process-performance objectives and which ones are good candidates to be improved. [PA161.IG101.SP102.SubP101.N101]

2. Investigate innovative improvements that may improve the organization's set of standard processes. [PA161.IG101.SP102.SubP102]

   Investigating innovative improvements involves the following:
   [PA161.IG101.SP102.SubP102.N101]

   - Systematically maintaining awareness of leading relevant technical work and technology trends
   - Periodically searching for commercially available innovative improvements

- Collecting proposals for innovative improvements from the projects and the organization
- Systematically reviewing processes and technologies used externally and comparing them to those used within the organization
- Identifying areas where innovative improvements have been used successfully, and reviewing data and documentation of experience using these improvements

3. Analyze potential innovative improvements to understand their effects on process elements and predict their influence on the process. [PA161.IG101.SP102.SubP103]

   Process performance models can provide a basis for analyzing possible effects of changes to process elements. [PA161.IG101.SP102.SubP103.N101]

   Refer to the Organizational Process Performance process area for more information about process performance models.
   [PA161.IG101.SP102.SubP103.N101.R101]

4. Analyze the costs and benefits of potential innovative improvements. [PA161.IG101.SP102.SubP104]

   Innovative improvements that have a very large cost-to-benefit ratio are rejected. [PA161.IG101.SP102.SubP104.N101]

5. Create process- and technology-improvement proposals for those innovative improvements that would result in improving the organization's processes or technologies. [PA161.IG101.SP102.SubP105]

6. Select the innovative improvements to be piloted before broadscale deployment. [PA161.IG101.SP102.SubP106]

   Since innovations, by definition, usually represent a major change, most innovative improvements will be piloted. [PA161.IG101.SP102.SubP106.N101]

7. Document the results of the evaluations of innovative improvements. [PA161.IG101.SP102.SubP107]

SP 1.3 Pilot Improvements

Pilot process and technology improvements to select which ones to implement. *[PA161.IG101.SP103]*

Pilots are performed to assess new and unproven major changes before they are broadly deployed, as appropriate. [PA161.IG101.SP103.N101]

The implementation of this specific practice may overlap with the implementation of the Implement the Action Proposals specific practice in the Causal Analysis and Resolution process area (e.g., when causal analysis and resolution is implemented organizationally or across multiple projects). [PA161.IG101.SP103.N102]

Typical Work Products

1. Pilot evaluation reports [PA161.IG101.SP103.W101]
2. Documented lessons learned from pilots [PA161.IG101.SP103.W102]

Subpractices

1. Plan the pilots. [PA161.IG101.SP103.SubP101]

   When planning pilots, it is critical to define criteria to be used for evaluating pilot results. [PA161.IG101.SP103.SubP101.N101]

2. Review and get relevant stakeholder agreement on the plans for the pilots. [PA161.IG101.SP103.SubP102]
3. Consult with and assist the people performing the pilots. [PA161.IG101.SP103.SubP103]
4. Perform each pilot in an environment that is characteristic of the environment present in a broadscale deployment. [PA161.IG101.SP103.SubP104]
5. Track the pilots against their plans. [PA161.IG101.SP103.SubP105]
6. Review and document the results of pilots. [PA161.IG101.SP103.SubP106]

   Reviewing and documenting the results of pilots usually involves the following: [PA161.IG101.SP103.SubP106.N101]

   - Deciding whether to terminate the pilot, re-plan and continue the pilot, or proceed with deploying the process and technology improvement
   - Updating the disposition of process- and technology-improvement proposals associated with the pilot
   - Identifying and documenting new process- and technology-improvement proposals as appropriate
   - Identifying and documenting lessons learned and problems encountered during the pilot

SP 1.4 Select Improvements for Deployment

Select process- and technology-improvement proposals for deployment across the organization. *[PA161.IG101.SP104]*

Selection of process- and technology-improvement proposals for deployment across the organization is based on quantifiable criteria derived from the organization's quality and process-performance objectives. [PA161.IG101.SP104.N101]

Typical Work Products

1. Process- and technology-improvement proposals selected for deployment [PA161.IG101.SP104.W101]

Subpractices

1. Prioritize the candidate process and technology improvements for deployment. [PA161.IG101.SP104.SubP101]

   Priority is based on an evaluation of the estimated cost-to-benefit ratio with regard to the quality and process-performance objectives. [PA161.IG101.SP104.SubP101.N101]

   Refer to the Organizational Process Performance process area for more information about quality and process-performance objectives. *[PA161.IG101.SP104.SubP101.N101.R101]*

2. Select the process and technology improvements to be deployed. [PA161.IG101.SP104.SubP102]

   The selection of the process improvements is based on their priorities and the available resources. [PA161.IG101.SP104.SubP102.N101]

3. Determine how each process and technology improvement will be deployed. [PA161.IG101.SP104.SubP103]

   Examples of how the process and technology improvements may be deployed include incorporating these improvements into the following: [PA161.IG101.SP104.SubP103.N101]

   - Organizational process assets
   - All or a subset of the organization's product families
   - All or a subset of the organization's projects
   - All or a subset of the organizational groups

4. Document the results of the selection process. [PA161.IG101.SP104.SubP104]

   The results of the selection process usually include the following: [PA161.IG101.SP104.SubP104.N101]

   - The selection criteria
   - The disposition of each proposal
   - The rationale for the disposition of each proposal
   - The assets to be changed for each selected proposal

SG 2 Deploy Improvements

Measurable improvements to the organization's processes and technologies are continually and systematically deployed. *[PA161.IG102]*

SP 2.1 Plan the Deployment

Establish and maintain the plans for deploying the selected process and technology improvements. *[PA161.IG102.SP101]*

The plans for deploying each process and technology improvement may be included in the organization's plan for organizational innovation and deployment or they may be documented separately.

[PA161.IG102.SP101.N101]

This specific practice plans the deployment of individual process and technology improvements. The Plan the Process generic practice addresses comprehensive planning that covers the specific practices in this process area. [PA161.IG102.SP101.N102]

Typical Work Products

1. Deployment plan for selected process and technology improvements [PA161.IG102.SP101.W101]

Subpractices

1. Determine how each process and technology improvement must be adjusted for organization-wide deployment. [PA161.IG102.SP101.SubP101]

   Process and technology improvements proposed within a limited context (e.g., for a single project) might have to be modified to work across the organization.

   [PA161.IG102.SP101.SubP101.N101]

2. Determine the changes necessary to deploy each process and technology improvement. [PA161.IG102.SP101.SubP102]

   Examples of changes needed to deploy a process and technology improvement include the following: [PA161.IG102.SP101.SubP102.N101]

   - Process descriptions, standards, and procedures
   - Development environments
   - Education and training
   - Skills
   - Existing commitments
   - Existing activities
   - Continuing support to end users
   - Organizational culture and characteristics

3. Identify strategies to address potential barriers to deploying each process and technology improvement. [PA161.IG102.SP101.SubP103]

4. Establish measures and objectives for determining the value of each process and technology improvement with respect to the organization's quality and process-performance objectives. [PA161.IG102.SP101.SubP104]

Examples of measures for determining the value of a process and technology improvement include the following: [PA161.IG102.SP101.SubP104.N101]

- Return on investment
- Time to recover the cost of the process or technology improvement
- Measured improvement in the project's or organization's process performance
- Number and types of project and organizational risks mitigated by the process or technology improvement
- Ability to respond quickly to changes in project requirements, market situations, and the business environment

Refer to the Measurement and Analysis process area for more information about establishing objectives for measurement and analysis, specifying the measures and analyses to be performed, obtaining and analyzing measures, and reporting results. *[PA161.IG102.SP101.SubP104.N101.R101]*

5. Document the plan for deploying each process and technology improvement. [PA161.IG102.SP101.SubP105]

6. Review and get agreement with relevant stakeholders on the plan for deploying each process and technology improvement. [PA161.IG102.SP101.SubP106]

7. Revise the plan for deploying each process and technology improvement as necessary. [PA161.IG102.SP101.SubP107]

SP 2.2 Manage the Deployment

Manage the deployment of the selected process and technology improvements. *[PA161.IG102.SP102]*

The implementation of this specific practice may overlap with the implementation of the Implement the Action Proposals specific practice in the Causal Analysis and Resolution process area (e.g., when causal analysis and resolution is implemented organizationally or across multiple projects). The primary difference is that in the Causal Analysis and Resolution process area, planning is done to manage the removal of the root causes of defects or problems from the project's defined processes. In the Organizational Innovation and Deployment process area, planning is done to manage the deployment of improvements to the organization's processes and technologies that can be quantified against the organization's business objectives. [PA161.IG102.SP102.N101]

Typical Work Products

1. Updated training materials (to reflect deployed process and technology improvements) [PA161.IG102.SP102.W101]
2. Documented results of process- and technology-improvement deployment activities [PA161.IG102.SP102.W102]
3. Revised process- and technology-improvement measures, objectives, priorities, and deployment plans [PA161.IG102.SP102.W103]

Subpractices

1. Monitor the deployment of the process and technology improvements using the deployment plan. [PA161.IG102.SP102.SubP101]
2. Coordinate the deployment of process and technology improvements across the organization. [PA161.IG102.SP102.SubP102]

   Coordinating deployment includes the following activities: [PA161.IG102.SP102.SubP102.N101]

   - Coordinating the activities of projects, support groups, and organizational groups for each process and technology improvement
   - Coordinating the activities for deploying related process and technology improvements

3. Quickly deploy process and technology improvements in a controlled and disciplined manner, as appropriate.

   [PA161.IG102.SP102.SubP103]

   Examples of methods for quickly deploying process and technology improvements include the following: [PA161.IG102.SP102.SubP103.N101]

   - Using red-lines, process change notices, or other controlled process documentation as interim process descriptions
   - Deploying process and technology improvements incrementally, rather than as a single deployment
   - Providing comprehensive consulting to early adopters of the process and technology improvement in lieu of revised formal training

4. Incorporate the process and technology improvements into organizational process assets, as appropriate. [PA161.IG102.SP102.SubP104]

   Refer to the Organizational Process Definition process area for more information about organizational process assets.

   [PA161.IG102.SP102.SubP104.R101]

5. Coordinate the deployment of the process and technology improvements into the projects' defined processes as appropriate.

   [PA161.IG102.SP102.SubP105]

Refer to the Organizational Process Focus process area for more information about deploying organizational process assets.
[PA161.IG102.SP102.SubP105.R101]

6. Provide consulting, as appropriate, to support deployment of the process and technology improvements. [PA161.IG102.SP102.SubP106]

7. Provide updated training materials to reflect the improvements to the organizational process assets. [PA161.IG102.SP102.SubP107]

   Refer to the Organizational Training process area for more information about training materials. *[PA161.IG102.SP102.SubP107.R101]*

8. Confirm that the deployment of all process and technology improvements is completed. [PA161.IG102.SP102.SubP108]

9. Determine whether the ability of the defined process to meet quality and process-performance objectives is adversely affected by the process and technology improvement, and take corrective action as necessary. [PA161.IG102.SP102.SubP109]

   Refer to the Quantitative Project Management process area for more information about quantitatively managing the project's defined process to achieve the project's established quality and process-performance objectives. *[PA161.IG102.SP102.SubP109.R101]*

10. Document and review the results of process- and technology-improvement deployment. [PA161.IG102.SP102.SubP110]

    Documenting and reviewing the results includes the following:
    [PA161.IG102.SP102.SubP110.N101]

    - Identifying and documenting lessons learned
    - Identifying and documenting new process- and technology-improvement proposals
    - Revising process- and technology-improvement measures, objectives, priorities, and deployment plans

SP 2.3 Measure Improvement Effects

Measure the effects of the deployed process and technology improvements. *[PA161.IG102.SP103]*

Refer to the Measurement and Analysis process area for more information about establishing objectives for measurement and analysis, specifying the measures and analyses to be performed, obtaining and analyzing measures, and reporting results.
[PA161.IG102.SP103.R101]

The implementation of this specific practice may overlap with the implementation of the Evaluate the Effect of Changes specific practice in the Causal Analysis and Resolution process area (e.g., when causal analysis and resolution is implemented organizationally or across multiple projects). [PA161.IG102.SP103.N101]

Typical Work Products

1. Documented measures of the effects resulting from the deployed process and technology improvements [PA161.IG102.SP103.W101]

Subpractices

1. Measure the actual cost, effort, and schedule for deploying each process and technology improvement. [PA161.IG102.SP103.SubP101]
2. Measure the value of each process and technology improvement. [PA161.IG102.SP103.SubP102]
3. Measure the progress toward achieving the organization's quality and process-performance objectives. [PA161.IG102.SP103.SubP103]
4. Analyze the progress toward achieving the organization's quality and process-performance objectives and take corrective action as needed. [PA161.IG102.SP103.SubP104]

   Refer to the Organizational Process Performance process area for more information about process performance analyses.

   [PA161.IG102.SP103.SubP104.R101]
5. Store the measures in the organization's measurement repository. [PA161.IG102.SP103.SubP105]

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the organizational innovation and deployment process.

[GP103]

Elaboration:

This policy establishes organizational expectations for identifying and deploying process and technology improvements that contribute to meeting quality and process-performance objectives. [PA161.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined organizational innovation and deployment process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the organizational innovation and deployment process. *[GP104]*

Elaboration:

This plan for performing the organizational innovation and deployment process differs from the deployment plans described in a specific practice in this process area. The plan called for in this generic practice would address the comprehensive planning for all of the specific practices in this process area, from collecting and analyzing improvement proposals all the way through to the measurement of improvement effects. In contrast, the deployment plans called for in the specific practice would address the planning needed for the deployment of individual process and technology improvements. [PA161.EL110]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the organizational innovation and deployment process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Examples of resources provided include the following tools: [PA161.EL102]

- Simulation packages
- Prototyping tools
- Statistical packages
- Dynamic systems modeling
- Subscriptions to online technology databases
- Process modeling tools

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the organizational innovation and deployment process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the organizational innovation and deployment process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA161.EL103]

- Planning, designing, and conducting pilots
- Cost/benefit analysis
- Technology transition
- Change management

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the organizational innovation and deployment process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA161.EL111]

- Documented lessons learned from pilots
- Revised process- and technology-improvement measures, objectives, priorities, and deployment plans
- Updated training material

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the organizational innovation and deployment process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include: [PA161.EL114]

- Reviewing process- and technology-improvement proposals that may have major impacts on process performance or on customer and end-user satisfaction
- Providing feedback to the organization on the status and results of the process- and technology-improvement deployment activities

The feedback typically involves: [PA161.EL115]

- Informing the people who submit process- and technology-improvement proposals about the disposition of their proposals
- Regularly informing relevant stakeholders about the plans and status for selecting and deploying process and technology improvements
- Preparing and distributing a summary of process- and technology-improvement selection and deployment activities

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the organizational innovation and deployment process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA161.EL106]

- Change in quality
- Change in process performance

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the organizational innovation and deployment process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational innovation and deployment process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA161.EL109]

- Selecting improvements
- Deploying improvements

Examples of work products reviewed include the following: [PA161.EL113]

- Deployment plans
- Revised process- and technology-improvement measures, objectives, priorities, and deployment plans
- Updated training material

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the organizational innovation and deployment process with higher level management and resolve issues. *[GP112]*

CAUSAL ANALYSIS AND RESOLUTION

Maturity Level 5

Purpose

The purpose of Causal Analysis and Resolution is to identify causes of defects and other problems and take action to prevent them from occurring in the future. [PA155]

Introductory Notes

The Causal Analysis and Resolution process area involves the following: [PA155.N101]

- Identifying and analyzing causes of defects and other problems
- Taking specific actions to remove the causes and prevent the occurrence of those types of defects and problems in the future

Causal analysis and resolution improves quality and productivity by preventing the introduction of defects into a product. Reliance on detecting defects after they have been introduced is not cost effective. It is more effective to prevent defects from being introduced by integrating causal analysis and resolution activities into each phase of the project. [PA155.N102]

Since defects and problems may have been previously encountered on other projects or in earlier phases or tasks of the current project, causal analysis and resolution activities are a mechanism for communicating lessons learned among projects. [PA155.N103]

The types of defects and other problems encountered are analyzed to identify any trends. Based on an understanding of the defined process and how it is implemented, the root causes of the defects and the future implications of the defects are determined. [PA155.N104]

Causal analysis may also be performed on problems unrelated to defects. For example, causal analysis may be used to improve quality attributes such as cycle time. Improvement proposals, simulations, dynamic systems models, engineering analyses, new business directives, or other items may initiate such analysis. [PA155.N105]

Sometimes it may be impractical to perform causal analysis on all defects. In these cases, tradeoffs are made between estimated investments and estimated returns in quality, productivity, and cycle time, and defect targets are selected. [PA155.N106]

A measurement process should already be in place. The defined measures can be used, though in some instances new measures may be needed to analyze the effects of the process change. [PA155.N107]

Refer to the Measurement and Analysis process area for more information about establishing objectives for measurement and analysis, specifying the measures and analyses to be performed, obtaining and analyzing measures, and reporting results. [PA155.N107.R101]

Causal Analysis and Resolution activities provide a mechanism for projects to evaluate their processes at the local level and look for improvements that can be implemented. [PA155.N108]

When improvements are judged to be effective, the information is extended to the organizational level. [PA155.N109]

Refer to the Organizational Innovation and Deployment process area for more information about improving organizational level processes through proposed improvements and action proposals. [PA155.N109.R101]

The informative material in this process area is written with the assumption that the specific practices are applied to a quantitatively managed process. The specific practices of this process area may be applicable, but with reduced value, if the assumption is not met. [PA155.N110]

See the definitions of "stable process" and "common cause of process variation" in Appendix C, the glossary. [PA155.N111]

Related Process Areas

Refer to the Quantitative Project Management process area for more information about the analysis of process performance and the creation of process capability measures for selected project processes. [PA155.R101]

Refer to the Organizational Innovation and Deployment process area for more information about the selection and deployment of improvements to organizational processes and technologies. [PA155.R102]

Refer to the Measurement and Analysis process area for more information about establishing objectives for measurement and analysis, specifying the measures and analyses to be performed, obtaining and analyzing measures, and reporting results. [PA155.R103]

Specific and Generic Goals

SG 1 **Determine Causes of Defects** [PA155.IG101]

Root causes of defects and other problems are systematically determined.

SG 2 **Address Causes of Defects** [PA155.IG102]

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

GG 3 **Institutionalize a Defined Process** [CL104.GL101]

The process is institutionalized as a defined process.

Practice-to-Goal Relationship Table

SG 1 Determine Causes of Defects [PA155.IG101]

SP 1.1	Select Defect Data for Analysis
SP 1.2	Analyze Causes

SG 2 Address Causes of Defects [PA155.IG102]

SP 2.1	Implement the Action Proposals
SP 2.2	Evaluate the Effect of Changes
SP 2.3	Record Data

GG 3 Institutionalize a Defined Process [CL104.GL101]

GP 2.1	(CO 1)	Establish an Organizational Policy
GP 3.1	(AB 1)	Establish a Defined Process
GP 2.2	(AB 2)	Plan the Process
GP 2.3	(AB 3)	Provide Resources
GP 2.4	(AB 4)	Assign Responsibility
GP 2.5	(AB 5)	Train People
GP 2.6	(DI 1)	Manage Configurations
GP 2.7	(DI 2)	Identify and Involve Relevant Stakeholders
GP 2.8	(DI 3)	Monitor and Control the Process
GP 3.2	(DI 4)	Collect Improvement Information
GP 2.9	(VE 1)	Objectively Evaluate Adherence
GP 2.10	(VE 2)	Review Status with Higher Level Management

Specific Practices by Goal

SG 1 **Determine Causes of Defects**

Root causes of defects and other problems are systematically determined.
[PA155.IG101]

A root cause is a source of a defect such that if it is removed, the defect is decreased or removed. [PA155.IG101.N101]

SP 1.1 Select Defect Data for Analysis

Select the defects and other problems for analysis. *[PA155.IG101.SP101]*

Typical Work Products

1. Defect and problem data selected for further analysis
   [PA155.IG101.SP101.W101]

Subpractices

1. Gather relevant defect data. [PA155.IG101.SP101.SubP101]

   Examples of relevant defect data may include the following: [PA155.IG101.SP101.SubP101.N101]

   - Project management problem reports requiring corrective action
   - Defects reported by the customer
   - Defects reported by end user
   - Defects found in peer reviews
   - Defects found in testing
   - Process capability problems

   Refer to the Verification process area for more information about work product verification. *[PA155.IG101.SP101.SubP101.N101.R101]*

   Refer to the Quantitative Project Management process area for more information about statistical management.
   [PA155.IG101.SP101.SubP101.N101.R102]

2. Determine which defects and other problems will be analyzed further. [PA155.IG101.SP101.SubP102]

   When determining which defects to analyze further, consider the impact of the defects, the frequency of occurrence, the similarity between defects, the cost of analysis, the time and resources needed, safety considerations, etc.
   [PA155.IG101.SP101.SubP102.N101]

   Examples of methods for selecting defects and other problems include the following: [PA155.IG101.SP101.SubP102.N102]

   - Pareto analysis
   - Histograms
   - Process capability analysis

SP 1.2 Analyze Causes

Perform causal analysis of selected defects and other problems and propose actions to address them. *[PA155.IG101.SP102]*

The purpose of this analysis is to develop solutions to the identified problems by analyzing the relevant data and producing action proposals for implementation. [PA155.IG101.SP102.N101]

Typical Work Products

1. Action proposal [PA155.IG101.SP102.W101]

Subpractices

1. Conduct causal analysis with the people who are responsible for performing the task. [PA155.IG101.SP102.SubP101]

   Causal analysis is performed with those people who have an understanding of the selected defect or problem under study, typically in meetings. The people who have the best understanding of the selected defect are typically those responsible for performing the task. [PA155.IG101.SP102.SubP101.N102]

   Examples of when to perform causal analysis include the following: [PA155.IG101.SP102.SubP101.N101]

   - When a stable process does not meet its specified quality and process-performance objectives
   - During the task, if and when problems warrant additional meetings
   - When a work product exhibits an unexpected deviation from its requirements

   Refer to the Quantitative Project Management process area for more information about achieving the project's quality and process-performance objectives. *[PA155.IG101.SP102.SubP101.N101.R101]*

2. Analyze selected defects and other problems to determine their root causes. [PA155.IG101.SP102.SubP102]

   Depending on the type and number of defects, it may make sense to first group the defects before identifying their root causes. [PA155.IG101.SP102.SubP102.N102]

   Examples of methods to determine root causes include the following: [PA155.IG101.SP102.SubP102.N101]

   - Cause-and-effect (fishbone) diagrams
   - Check sheets

3. Group the selected defects and other problems based on their root causes. [PA155.IG101.SP102.SubP103]

Examples of cause groups, or categories, include the following:
[PA155.IG101.SP102.SubP103.N101]

- Inadequate training
- Breakdown of communications
- Not accounting for all details of the task
- Making mistakes in manual procedures (e.g., typing)
- Process deficiency

4. Propose and document actions that need to be taken to prevent the future occurrence of similar defects or other problems.
[PA155.IG101.SP102.SubP104]

Examples of proposed actions include changes to the following:
[PA155.IG101.SP102.SubP104.N101]

- The process in question
- Training
- Tools
- Methods
- Communications
- Work products

Examples of specific actions include the following: [PA155.IG101.SP102.SubP104.N102]

- Providing training in common problems and techniques for preventing them
- Changing a process so that error-prone steps do not occur
- Automating all or part of a process
- Reordering process activities
- Adding process steps to prevent defects, such as task kickoff meetings to review common defects and actions to prevent them

An action proposal usually documents the following: [PA155.IG101.SP102.SubP104.N103]

- Originator of the action proposal
- Description of the problem
- Description of the defect cause
- Defect cause category
- Phase when the problem was introduced
- Phase when the defect was identified
- Description of the action proposal
- Action proposal category

SG 2 Address Causes of Defects

Root causes of defects and other problems are systematically addressed to prevent their future occurrence. *[PA155.IG102]*

Projects operating according to a well-defined process will systematically analyze the operation where problems still occur and implement process changes to eliminate root causes of selected problems. [PA155.IG102.N101]

SP 2.1 Implement the Action Proposals

Implement the selected action proposals that were developed in causal analysis. *[PA155.IG102.SP101]*

Action proposals describe the tasks necessary to remove the root causes of the analyzed defects or problems and avoid their reoccurrence. [PA155.IG102.SP101.N101]

Only changes that prove to be of value should be considered for broad implementation. [PA155.IG102.SP101.N102]

Typical Work Products

1. Action proposals selected for implementation [PA155.IG102.SP101.W101]
2. Improvement proposals [PA155.IG102.SP101.W102]

Subpractices

1. Analyze the action proposals and determine their priorities.
   [PA155.IG102.SP101.SubP101]

   Criteria for prioritizing action proposals include the following:
   [PA155.IG102.SP101.SubP101.N101]

   - Implications of not addressing the defects
   - Cost to implement process improvements to prevent the defects
   - Expected impact on quality
2. Select the action proposals that will be implemented.
   [PA155.IG102.SP101.SubP102]
3. Create action items for implementing the action proposals.
   [PA155.IG102.SP101.SubP103]

Examples of information provided in an action item include the following:
[PA155.IG102.SP101.SubP103.N101]

- Person responsible for implementing it
- Description of the areas affected by it
- People who are to be kept informed of its status
- Next date that status will be reviewed
- Rationale for key decisions
- Description of implementation actions
- Time and cost for identifying the defect and correcting it
- Estimated cost of not fixing the problem

To implement the action proposals, the following tasks must be done:
[PA155.IG102.SP101.SubP103.N102]

- Make assignments
- Coordinate the persons doing the work
- Review the results
- Track the action items to closure

Experiments may be conducted for particularly complex changes.
[PA155.IG102.SP101.SubP103.N103]

Examples of experiments include the following: [PA155.IG102.SP101.SubP103.N105]

- Using a temporarily modified process
- Using a new tool

Action items may be assigned to members of the causal analysis team, members of the project team, or other members of the organization. [PA155.IG102.SP101.SubP103.N104]

4. Identify and remove similar defects that may exist in other processes and work products. [PA155.IG102.SP101.SubP104]

5. Identify and document improvement proposals for the organization's set of standard processes. [PA155.IG102.SP101.SubP105]

Refer to the Organizational Innovation and Deployment process area for more information about the selection and deployment of improvement proposals for the organization's set of standard processes. *[PA155.IG102.SP101.SubP105.R101]*

SP 2.2 Evaluate the Effect of Changes

Evaluate the effect of changes on process performance.

[PA155.IG102.SP102]

Refer to the Quantitative Project Management process area for more information about analyzing process performance and creating process capability measures for selected processes. [PA155.IG102.SP102.R101]

Once the changed process is deployed across the project, the effect of the changes must be checked to gather evidence that the process change has corrected the problem and improved performance. [PA155.IG102.SP102.N101]

Typical Work Products

1. Measures of performance and performance change [PA155.IG102.SP102.W101]

Subpractices

1. Measure the change in the performance of the project's defined process as appropriate. [PA155.IG102.SP102.SubP101]

   This subpractice determines whether the selected change has positively influenced the process performance and by how much. [PA155.IG102.SP102.SubP101.N101]

   An example of a change in the performance of the project's defined design process would be the change in the defect density of the design documentation, as statistically measured through peer reviews before and after the improvement has been made. On a statistical process control chart, this would be represented by a change in the mean. [PA155.IG102.SP102.SubP101.N102]

2. Measure the capability of the project's defined process as appropriate. [PA155.IG102.SP102.SubP102]

   This subpractice determines whether the selected change has positively influenced the ability of the process to meet its quality and process-performance objectives, as determined by relevant stakeholders. [PA155.IG102.SP102.SubP102.N101]

   An example of a change in the capability of the project's defined design process would be a change in the ability of the process to stay within its process-specification boundaries. This can be statistically measured by calculating the range of the defect density of design documentation, as collected in peer reviews before and after the improvement has been made. On a statistical process control chart, this would be represented by lowered control limits. [PA155.IG102.SP102.SubP102.N102]

SP 2.3 Record Data

Record causal analysis and resolution data for use across the project and organization. *[PA155.IG102.SP103]*

Data are recorded so that other projects and organizations can make appropriate process changes and achieve similar results.
[PA155.IG102.SP103.N101]

Record the following: [PA155.IG102.SP103.N102]

- Data on defects and other problems that were analyzed
- Rationale for decisions
- Action proposals from causal analysis meetings
- Action items resulting from action proposals
- Cost of the analysis and resolution activities
- Measures of changes to the performance of the defined process resulting from resolutions

Typical Work Products

1. Causal analysis and resolution records [PA155.IG102.SP103.W101]

GG 3 Institutionalize a Defined Process [CL104.GL101]

The process is institutionalized as a defined process.

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the causal analysis and resolution process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for identifying and systematically addressing root causes of defects and other problems.
[PA155.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined causal analysis and resolution process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the causal analysis and resolution process. *[GP104]*

Elaboration:

This plan for performing the causal analysis and resolution process differs from the action proposals and associated action plans described in the specific practice in this process area. The plan called for in this generic process would address the organization's overall causal analysis and resolution process. In contrast, the process action proposals and associated action plans address the activities needed to remove the root cause under study. [PA155.EL111]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the causal analysis and resolution process, developing the work products, and providing the services of the process. *[GP105]*

Elaboration:

Examples of resources provided include the following tools: [PA155.EL102]

- Database systems
- Process modeling tools
- Statistical analysis packages
- Tools, methods, and analysis techniques (e.g., Ishakawa or fishbone diagram, Pareto analysis, histograms, process capability studies, control charts)

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the causal analysis and resolution process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the causal analysis and resolution process as needed. *[GP107]*

Elaboration:

Examples of training topics include the following: [PA155.EL103]

- Quality management methods (e.g., root cause analysis)

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the causal analysis and resolution process under appropriate levels of configuration management. *[GP109]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA155.EL104]

- Action proposals
- Action proposals selected for implementation
- Causal analysis and resolution records

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the causal analysis and resolution process as planned. *[GP124]*

Elaboration:

Examples of activities for stakeholder involvement include the following: [PA155.EL110]

- Conducting causal analysis
- Assessing the action proposals

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the causal analysis and resolution process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling include the following: [PA155.EL105]

- Number of root causes removed
- Change in quality or process performance per instance of the causal analysis and resolution process

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the causal analysis and resolution process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the causal analysis and resolution process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA155.EL106]

- Determining causes of defects
- Addressing causes of defects

Examples of work products reviewed include the following: [PA155.EL109]

- Action proposals selected for implementation
- Causal analysis and resolution records

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the causal analysis and resolution process with higher level management and resolve issues. *[GP112]*

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Sources Not Publicly Available

The following documents were used in the development of the CMMI Product Suite but were never released for public use.

Integrated Product Development Capability Maturity Model, Version 0.98, Enterprise Process Improvement Collaboration and Software Engineering Institute, Carnegie Mellon University, 1997. [SR111]

B. Acronyms

AB	Ability to Perform (common feature)
ARC	Appraisal Requirements for CMMI
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 Integration
CMMI-SE/SW	Capability Maturity Model Integration for Systems Engineering and Software Engineering
CO	Commitment to Perform (common feature)
COTS	commercial off the shelf
CPM	critical path method
DAR	Decision Analysis and Resolution (process area)
DI	Directing Implementation (common feature)
DoD	Department of Defense
EIA/IS	Electronic Industries Alliance Interim Standard
GG	generic goal
GP	generic practice
IDEAL	Initiating, Diagnosing, Establishing, Acting, Learning
IPD-CMM	Integrated Product Development Capability Maturity Model
IPM	Integrated Project Management (process area)

IPPD	Integrated Product and Process Development
IPT	Integrated Product Team
ISO	International Organization for Standardization
ISO/IEC	International Organization for Standardization and International Electrotechnical Commission
IT	Integrated Teaming (process area)
MA	Measurement and Analysis (process area)
MOA	Memorandum of Agreement
OEI	Organizational Environment for Integration (process area)
OID	Organizational Innovation and Deployment (process area)
OPD	Organizational Process Definition (process area)
OPF	Organizational Process Focus (process area)
OPP	Organizational Process Performance (process area)
OT	Organizational Training (process area)
OUSD/AT&L	Office of the Under Secretary of Defense, Acquisition, Technology, and Logistics
PA	process area
PAIS	Process Appraisal Information System
PERT	Program Evaluation and Review Technique
PI	Product Integration (process area)
PMC	Project Monitoring and Control (process area)
PP	Project Planning (process area)
PPQA	Process and Product Quality Assurance (process area)
QFD	Quality Function Deployment
QPM	Quantitative Project Management (process area)
RD	Requirements Development (process area)

REQM	Requirements Management (process area)
RSKM	Risk Management (process area)
SA-CMM	Software Acquisition Capability Maturity Model
SAM	Supplier Agreement Management (process area)
SCAMPI	Standard CMMI Appraisal 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
SG	specific goal
SP	specific practice
SW-CMM	Capability Maturity Model for Software
TS	Technical Solution (process area)
VAL	Validation (process area)
VE	Verifying Implementation (common feature)
VER	Verification (process area)
WBS	work breakdown structure

C. Glossary

The CMMI glossary defines many of the basic terms used in the CMMI models. Glossary entries are typically multiple-word terms consisting of a noun and one or more restrictive modifiers (e.g., instead of defining "tailoring," the following are defined: "CMMI model tailoring," "CMMI appraisal tailoring," and "tailoring guidelines"). (There are some exceptions to this rule that account for one-word terms in the glossary.) [FM113.T101]

The glossary was developed using defined criteria for the selection of terms and definitions. Some terms were not included in the glossary because they were used in only one process area or because the term was used in an everyday sense. In either case, the use of the term is explained in the process area. [FM113.T102]

To be considered for inclusion in the glossary of CMMI models, terms must meet all of the following conditions: [FM113.T103]

Condition 1 - The entry must appear in the CMMI models. The glossary does not include words that are self explanatory in the context of the CMMI product or that, through popular use, already are widely understood by model users. Terms only used as examples and which were not concepts critical to the use of CMMI models were also excluded. However, if there was any doubt as to how widely understood a term was, the term was included in the glossary. [FM113.T104]

Condition 2 - The definition of the term is not satisfied by common dictionary definition(s). The best reference source for term definitions is a standard English dictionary. Therefore, once a term was identified in the CMMI Product Suite, it (or its component words) was searched for in Miriam-Webster's Online Collegiate Dictionary (http://www.m-w.com). If the definition found there accurately characterized how the term was being used in CMMI products, the term was left out of the glossary because there was no compelling need to replicate common definitions found in the Webster's dictionary. [FM113.T105]

Condition 3 - In some instances, terms used in the CMMI models are unique to the CMMI context. In these instances, original definitions not found in other contexts were created. When selecting or creating CMMI definitions, great care was taken to ensure that the definitions did not have any of the following characteristics: [FM113.T106]

- Circular definitions

- Self-defining definitions wherein a term is used to define itself
- Terms that are differentiated when they really are synonyms according to the standard English dictionary
- Overly restrictive definitions that would hinder use of the terms generally understood by the public in more commonplace situations
- Definitions that provide explanatory information that more rightly belong elsewhere in a model

When selecting definitions for terms in the CMMI glossary, definitions from recognized sources were used where possible. Definitions were first selected from existing sources that have a widespread readership in the software development, systems development, and IPPD disciplines. If a definition was selected from one of these sources, a note at the end of the definition in brackets (for example, [ISO 9000]) was included. The order of precedence used when selecting definitions was as follows: [FM113.T109]

1. Webster's Dictionary
2. ISO/IEC 9000
3. ISO/IEC 12207
4. ISO/IEC 15504
5. ISO/IEC 15288
6. CMMI Source Models [FM113.T115]
   - IPD-CMM v0.98
   - EIA/IS 731 (SECM)
   - SW-CMM v 2, draft C
7. CMMI A-Spec
8. IEEE
9. SW-CMM v1.1
10. EIA 632
11. SA-CMM
12. FAA-CMM
13. P-CMM [FM113.T116]

The Glossary was developed recognizing the importance of using terminology that all model users can understand. It is also recognized that words and terms can have different meanings in different contexts and environments. The glossary in CMMI models is designed to document the meanings of words and terms that should have the widest use and understanding by users of CMMI products. [FM113.T117]

ability to perform — A common feature of CMMI model process areas with a staged representation that groups the generic practices related to ensuring that the project and/or organization has the resources it needs.

acceptance criteria — The criteria that a product or product component must satisfy to be accepted by a user, customer, or other authorized entity.

acceptance testing — Formal testing conducted to enable a user, customer, or other authorized entity to determine whether to accept a product or product component. (See "unit testing.")

achievement profile — In the continuous representation, a list of process areas and their corresponding capability levels that represent the organization's progress for each process area while advancing through the capability levels. (See "target staging," "capability level profile," and "target profile.")

acquisition — The process of obtaining, through contract, any discrete action or proposed action by the acquisition entity that would commit to invest (appropriated funds) for obtaining products and services.

acquisition strategy — The specific approach to acquiring products and services that is based on considerations of supply sources, acquisition methods, requirements specification types, contract or agreement types, and the related acquisition risk.

adequate — See Chapter 3 for an explanation of how "adequate," "appropriate," and "as needed" are used in the CMMI Product Suite.

advanced practices — In the continuous representation, all the specific practices with a capability level of two or higher.

agreement/contract requirements — All technical and nontechnical requirements related to an acquisition.

allocated requirement — Requirement that levies all or part of the performance and functionality of a higher level requirement on a lower level architectural element or design component.

alternative practice — A practice that is a substitute for one or more generic or specific practices contained in CMMI models that achieves an equivalent effect toward satisfying the generic or specific goal associated with model practices. Alternative practices are not necessarily one-for-one replacements for the generic or specific practices.

appraisal

See Chapter 3 for an explanation of how "appraisal" is used in the CMMI Product Suite.

appraisal findings

The conclusions of an appraisal that identify the most important issues, problems, or opportunities within the appraisal scope. Findings include, at a minimum, strengths and weaknesses based on valid observations.

appraisal participants

Members of the organizational unit who participate in providing information during the appraisal.

appraisal rating

As used in CMMI appraisal materials, the value assigned by an appraisal team to either (1) a CMMI goal or process area, (2) the capability level of a process area, or (3) the maturity level of an organizational unit. The rating is determined by enacting the defined rating process for the appraisal method being employed.

appraisal reference model

As used in CMMI appraisal materials, the CMMI model to which an appraisal team correlates implemented process activities.

appraisal scope

The definition of the boundaries of the appraisal encompassing the organizational limits and the CMMI model limits.

appraisal team leader

A person who leads the activities of an appraisal and has satisfied the qualification criteria for experience, knowledge, and skills defined by the appraisal method.

appropriate

See Chapter 3 for an explanation of how "adequate," "appropriate," and "as needed" are used in the CMMI Product Suite.

as needed

See Chapter 3 for an explanation of how "adequate," "appropriate," and "as needed" are used in the CMMI Product Suite.

assessment

See Chapter 3 for an explanation of how "assessment" is used in the CMMI Product Suite.

assignable cause of process variation

In CMMI, the term "special cause of process variation" is used in place of "assignable cause of process variation" to ensure consistency. Both terms are defined identically. (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.

base measure	A distinct property or characteristic of an entity and the method for quantifying it. (See "derived measures.")
base practices	In the continuous representation, all the specific practices with a capability level of 1.
baseline	(See "configuration baseline," "process performance baseline," and "product baseline.")
business objectives	(See "organization's business objectives.")
capability evaluation	An appraisal by a trained team of professionals used as a discriminator to select suppliers, for contract monitoring, or for incentives. Evaluations are used to help decision makers make better acquisition decisions, improve subcontractor performance, and provide insight to a purchasing organization.
capability level	Achievement of process improvement within an individual process area. A capability level is defined by the appropriate specific and generic practices for a process area. (See "maturity level," "process area," generic practice," and "generic goal.")
capability level profile	In the continuous representation, a list of process areas and their corresponding capability levels. (See "target staging," "capability level profile," "achievement profile," and "target profile.") The profile may be an achievement profile when it represents the organization's progress for each process area while advancing through the capability levels. Or, the profile may be a target profile when it represents an objective for process improvement.
capability maturity model	A capability maturity model (CMM) contains the essential elements of effective processes for one or more disciplines. It also describes an evolutionary improvement path from ad hoc, immature processes to disciplined, mature processes 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," and "statistically managed process.")
causal analysis	The analysis of defects to determine their cause.

change management

Judicious use of means to effect a change, or proposed change, on a product or service. (See "configuration management.")

CMMI appraisal tailoring

Selection of options within the appraisal method for use in a specific instance.

The intent of appraisal tailoring is to assist an organization in aligning application of the method with its business objectives.

CMMI Framework

See Chapter 3 for an explanation of how "CMMI Framework" is used in the CMMI Product Suite.

CMMI model

See Chapter 3 for an explanation of how "CMMI model" is used in the CMMI Product Suite.

CMMI model component

Any of the main architectural elements that compose 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 a subset of a CMMI model for the purpose of making it suitable for a specific application. The intent of model tailoring is to assist an organization in aligning application of a model with its business objectives.

CMMI Product Suite

See Chapter 3 for an explanation of how "CMMI Product Suite" is used in the CMMI Product Suite. (See "CMMI Framework.")

commitment to perform

A common feature of CMMI model process areas with a staged representation that groups the generic practices related to creating policies and securing sponsorship.

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.")

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 "audit" and "configuration item.")

configuration baseline

The configuration information formally designated at a specific time during a product's or product component's life. Configuration baselines, plus approved changes from those baselines, constitute the current configuration information. (See "product 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 "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. (See "configuration item.") Configuration control boards are also known as "change control boards."

configuration identification

An element of configuration management consisting of selecting the configuration items for a product, assigning unique identifiers to them, and recording their functional and physical characteristics in technical documentation. (See "configuration management," "configuration item," and "product.")

configuration item

An aggregation of work products that is designated for configuration management and treated as a single entity in the configuration management process. (See "configuration management.")

configuration management

A discipline applying technical and administrative direction and surveillance to (1) identify and document the functional and physical characteristics of a configuration item, (2) control changes to those characteristics, (3) record and report change processing and implementation status, and (4) verify compliance with specified requirements. [IEEE Std 610.1990] (See "configuration identification," "configuration control," "configuration status accounting," and "configuration audit.")

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 "configuration management" and "configuration identification.")

continuous representation

A capability maturity model structure wherein capability levels provide a recommended order for approaching process improvement within each specified process area. (See "staged representation," "capability level," and "process area.")

contractor

(See "supplier.")

corrective action

Acts or deeds used to remedy a situation, remove an error, or adjust a condition.

COTS

Items that can be purchased from a commercial vendor. (COTS stands for "commercial off the shelf.")

customer

See Chapter 3 for an explanation of how "customer" is used in the CMMI Product Suite.

data management

Principles, processes, and systems for the sharing and management of data.

defect density

Number of defects per unit of product size (e.g., problem reports per 1000 lines of code).

defined process

See Chapter 3 for an explanation of how "defined process" is used in the CMMI Product Suite.

derived measures

Data resulting from the mathematical function of two or more base measures. (See "base measure.")

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 product component. Derived requirements can also arise during analysis and design of components of the product or system. (See "product requirements.")

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.

development

See Chapter 3 for an explanation of how "development" is used in the CMMI Product Suite.

developmental plan

A plan for guiding, implementing, and controlling the design and development of one or more products. (See "project plan" and "product life cycle.")

directing implementation

A common feature of CMMI model process areas with a staged representation that groups the generic practices related to managing the performance of the process, managing the integrity of its work products, and involving relevant stakeholders.

discipline amplification

See Chapter 2 for an explanation of how "discipline amplification" is used in the CMMI Product Suite.

enterprise

See Chapter 3 for an explanation of how "enterprise" is used in the CMMI Product Suite.

entry criteria

States of being that must be present before an effort can begin successfully.

equivalent staging

Equivalent staging is a target staging, created using the continuous representation that is defined so that the results of using the target staging can be compared to the maturity levels of the staged representation. (See "target staging," "maturity level," "capability level profile," and "target profile.")

Such staging permits benchmarking of progress among organizations, enterprises, and projects, regardless of the CMMI representation used. The organization may implement components of CMMI models beyond those reported as part of equivalent staging. Equivalent staging is only a measure to relate how the organization is compared to other organizations in terms of maturity levels.

establish and maintain

See Chapter 3 for an explanation of how "establish and maintain" is used in the CMMI Product Suite.

evidence

(See "objective evidence.")

executive

(See "senior manager.")

exit criteria

States of being that must be present before an effort can end successfully.

expected CMMI components

CMMI components that explain what may be done to satisfy a required CMMI component. Model users can implement the expected components explicitly or implement equivalent alternative practices to these components. Specific and generic practices are expected model components.

finding (See "appraisal findings.")

formal evaluation process In the Decision Analysis and Resolution process area, see the definition of a "formal evaluation process" in the introductory notes.

framework (See "CMMI Framework.")

functional analysis Examination of a defined function to identify all the subfunctions 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 subfunctions. (See "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 their design constraints.

generic goal See Chapter 2 for an explanation of how "generic goal" is used in the CMMI Product Suite.

generic practice See Chapter 2 for an explanation of how "generic practice" is used in the CMMI Product Suite.

generic practice elaboration See Chapter 2 for an explanation of how "generic practice elaboration" is used in the CMMI Product Suite.

goal See Chapter 3 for an explanation of how "goal" is used in the CMMI Product Suite.

incomplete process A process that is not performed or is only performed partially (also known as capability level 0). One or more of the specific goals of the process area are not satisfied.

independent group In the Process and Product Quality Assurance process area, see the discussion of a "group that is independent" in the introductory notes.

informative CMMI components

CMMI components that help model users understand the required and expected components of a model. These components may contain examples, detailed explanations, or other helpful information. Subpractices, notes, references, goal titles, practice titles, sources, typical work products, discipline amplifications, and generic practice elaborations are informative model components.

institutionalization

The ingrained way of doing business that an organization follows routinely as part of its corporate culture.

Integrated Product and Process Development

A systematic approach to product development that achieves a timely collaboration of relevant stakeholders throughout the product life cycle to better satisfy customer needs.

integrated team

A group of people with complementary skills and expertise who are committed to delivering specified work products in timely collaboration. Integrated team members provide skills and advocacy appropriate to all phases of the work products' life and are collectively responsible for delivering the work products as specified. An integrated team should include empowered representatives from organizations, disciplines, and functions that have a stake in the success of the work products.

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 that the proposed changes to these characteristics are evaluated and approved prior to implementation. [IEEE 828-1983] (See "configuration management" and "configuration item.")

lead appraiser

As used in the CMMI Product Suite, a person who has achieved recognition from an authorizing body to perform as an appraisal team leader for a particular appraisal method.

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

See Chapter 3 for an explanation of how "managed process" is used in the CMMI Product Suite.

manager

See Chapter 3 for an explanation of how "manager" is used in the CMMI Product Suite.

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" and "process area.")

memorandum of agreement

Binding documents of understanding or agreements between two or more parties. (Also known as a "memorandum of understanding.")

natural bounds

The inherent process reflected by measures 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 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.

nontechnical requirements

Contractual provisions, commitments, conditions, and terms that affect how products or services are to be acquired. Examples include products to be delivered, data rights for delivered commercial off-the-shelf (COTS) non-developmental items (NDIs), delivery dates, and milestones with exit criteria. Other nontechnical requirements include training requirements, site requirements, and deployment schedules.

objective

See Chapter 3 for an explanation of how "objective" is used in the CMMI Product Suite.

objective evidence

As used in CMMI appraisal materials, qualitative or quantitative information, records, or statements of fact pertaining to the characteristics of an item or service or to the existence and implementation of a process element, which are based on observation, measurement, or test and which are verifiable.

objectively evaluate

To review activities and work products against criteria that minimize subjectivity and bias by the reviewer. An example of an objective evaluation is an audit against requirements, standards, or procedures by an independent quality assurance function. (See "audit.")

observation

As used in CMMI appraisal materials, a written record that represents the appraisal team members' understanding of information either seen or heard during the appraisal data collection activities. The written record may take the form of a statement or may take alternative forms as long as the information content is preserved.

operational concept

A general description of the way in which an entity is used or operates. (Also known as "concept of operations.")

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 product components. Operational scenarios are used to evaluate the requirements and design of the system and to verify and validate the system.

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," "defined process," and "common cause of process variation.")

organization

See Chapter 3 for an explanation of how "organization" is used in the CMMI Product Suite.

organization's business objectives

Senior-management-developed strategies designed to ensure an organization's continued existence and enhance its profitability, market share, and other factors influencing the organization's success. (See "quantitative objective" and "quality and process-performance objectives.")

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 product's first or second phase of development, reducing the number of customer-reported defects, etc., when applied to systems-engineering activities.

organization's measurement repository

See Chapter 3 for an explanation of how "organization's measurement repository" is used in the CMMI Product Suite.

organization's process asset library

See Chapter 3 for an explanation of how "organization's process asset library" is used in the CMMI Product Suite.

organization's set of standard processes

See Chapter 3 for an explanation of how "organization's set of standard processes" is used in the CMMI Product Suite. (See "defined process" and "process element.")

organizational maturity

The extent to which an organization has explicitly and consistently deployed processes that are documented, managed, measured, controlled, and continually improved. Organizational maturity may be measured via appraisals.

organizational policy

A guiding principle typically established by senior management that is adopted by an organization to influence and determine decisions.

organizational process assets

See Chapter 3 for an explanation of how "organizational process assets" is used in the CMMI Product Suite.

organizational unit

That part of an organization that is the subject of an appraisal (also known as the organizational scope of the appraisal).

An organizational unit deploys one or more processes that have a coherent process context and operates within a coherent set of business objectives. An organizational unit is typically part of a larger organization, although in a small organization, the organizational unit may be the whole organization.

outsourcing

(See "acquisition.")

peer review

See Chapter 3 for an explanation of how "peer review" is used in the CMMI Product Suite.

performance parameters

The measures of effectiveness and other key measures 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.

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.

policy	(See "organizational policy.")
process	See Chapter 3 for an explanation of how "process" is used in the CMMI Product Suite.
process action plan	In the Organizational Process Focus process area, see the definition of "process action plan" in the introductory notes.
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 and technology improvements	In the Organizational Innovation and Deployment process area, see the discussion of "process and technology improvements" in the introductory notes.
process architectures	See Chapter 3 for an explanation of how "process architectures" is used in the CMMI Product Suite.
process area	See Chapter 2 for an explanation of how "process area" is used in the CMMI Product Suite.
process asset	Anything that the organization considers useful in attaining the goals of a process area. (See "organizational process assets.")
process asset library	A collection of process asset holdings that can be used by an organization or project. (See "organization's process asset library.")
process attribute	A measurable characteristic of process capability applicable to any process.
process capability	The range of expected results that can be achieved by following a process. [EIA/IS 731, V1.0]
process context	The set of factors, documented in the appraisal input, that influences the judgment and comparability of appraisal ratings. These include, but are not limited to, the size of the organizational unit to be appraised; the demographics of the organizational unit; the application discipline of the products or services; the size, criticality, and complexity of the products or services; and the quality characteristics of the products or services.

process definition

The act of defining and describing a process. The result of process definition is a process description. (See "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 a process. A process may be defined in terms of subprocesses or process elements. A subprocess can be further decomposed; a process element cannot.

Each process element covers a closely related set of activities (for example, estimating element, peer review element). Process elements can be portrayed using templates to be completed, abstractions to be refined, or descriptions to be modified or used. A process element can be an activity or task.

process group

A collection of specialists that facilitate the definition, maintenance, and improvement of the process(es) used by the organization.

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 objectives

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 "quantitative objective" and "organization's business objectives.")

process-improvement plan

In the Organizational Process Focus process area, see the definition of "process-improvement plan" in the introductory notes.

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. 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 process owner is the person (or team) responsible for the description of the defined process. A process may therefore have multiple owners at different levels of responsibility. (See "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 "process performance.")

process performance model

A description of the relationships among attributes of a process and its work products that are developed from historical process performance data and calibrated using collected process and product measures from the project and which are used to predict results to be achieved by following a process.

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 "process description," "organization's set of standard processes," and "defined process.")

product

See Chapter 3 for an explanation of how "product" is used in the CMMI Product Suite.

product baseline

In configuration management, the initial approved technical data package (including, for software, the source code listing) defining a configuration item during the production, operation, maintenance, and logistic support of its life cycle. (See "configuration management" and "configuration item.")

product component	See Chapter 3 for an explanation of how "product component" is used in the CMMI Product Suite.
product-component requirements	Product-component requirements provide a complete specification of a product component, including fit, form, function, performance, and any other requirement.
product life cycle	See Chapter 3 for an explanation of how "product life cycle" is used in the CMMI Product Suite.
product line	A group of products sharing a common, managed set of features that satisfy specific needs of a selected market or mission.
product-related life-cycle processes	Processes associated with a product throughout one or more phases of its life (i.e., from conception through disposal), such as the manufacturing and support processes.
product requirements	A refinement of the customer requirements into the developers' language, making implicit requirements into explicit derived requirements. (See "product-component requirements" and "derived requirements.") The developer uses the product requirements to guide the design and building of the product.
product suite	(See "CMMI Product Suite.")
profile	(See "achievement profile" and "target profile.")
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.")
project	See Chapter 3 for an explanation of how "project" is used in the CMMI Product Suite.
project manager	See Chapter 3 for an explanation of how "project manager" is used in the CMMI Product Suite.
project plan	In the Project Planning process area, see the definition of "project plan" in the introductory notes.
project progress and performance	What a project achieves with respect to implementing project plans, including effort, cost, schedule, and technical performance.

project's defined process

In the Integrated Project Management process area, see the definition of "project's defined process" in the introductory notes and in the Establish the Project's Defined Process specific practice.

prototype

A preliminary type, form, or instance of a product or product component that serves as a model for later stages or for the final, complete version of the product. This model (physical, electronic, digital, analytical, etc.) can be used for the following (and other) purposes:

- assessing the feasibility of a new or unfamiliar technology
- assessing or mitigating technical risk
- validating requirements
- demonstrating critical features
- qualifying a product
- qualifying a process
- characterizing performance or product features
- elucidating physical principles

quality

The ability of a set of inherent characteristics of a product, product component, or process to fulfill requirements of customers.

quality and process-performance objectives

See Chapter 3 for an explanation of how "quality and process-performance objectives" is used in the CMMI Product Suite.

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. [ISO 8402-1994] (See "quality assurance.")

quantitative objective

Desired target value expressed as quantitative measures. (See "quality and process-performance objectives" and "process-improvement objectives.")

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 project. (See "optimizing process," "defined process," and "statistically managed process.")

rating

(See "appraisal rating.")

reference

See Chapter 2 for an explanation of how "reference" is used in the CMMI Product Suite.

reference model

A model that is used as a benchmark for measuring some attribute.

relevant stakeholder

See Chapter 3 for an explanation of how "relevant stakeholder" is used in the CMMI Product Suite.

representation

In Chapter 1, see the definitions of "staged representation" and "continuous representation."

required CMMI components

CMMI components that are essential to achieving process improvement in a given process area. These components are used in appraisals to determine process capability. Specific goals and generic goals are required model components.

requirement

(1) A condition or capability needed by a user to solve a problem or achieve an objective. (2) A condition or capability that must be met or possessed by a product or product component to satisfy a contract, standard, specification, or other formally imposed documents. (3) A documented representation of a condition or capability as in (1) or (2). [IEEE 610.12-1990]

requirements analysis

The determination of product-specific performance and functional characteristics based on analyses of customer needs, expectations, and constraints; operational concept; projected utilization environments for people, products, and processes; and measures of effectiveness.

requirements elicitation

Using systematic techniques, like prototypes and structured surveys, to proactively identify and document customer and end-user needs.

requirements management	The management of all requirements received by or generated by the project, including both technical and nontechnical requirements as well as those requirements levied on the project by the organization.
requirements traceability	The evidence of an association between a requirement and its source 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 analysis	The evaluation, classification, and prioritization of risks.
risk identification	An organized, thorough approach to seek out probable or realistic risks in achieving objectives.
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 management strategy	An organized, technical approach 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. Typically, risk management is performed for project, organization, or product-developing organizational units.
root cause	A root cause is a source of a defect such that if it is removed, the defect is decreased or removed.
senior manager	See Chapter 3 for an explanation of how "senior manager" is used in the CMMI Product Suite.
shared vision	See Chapter 3 for an explanation of how "shared vision" is used in the CMMI Product Suite.
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).
solicitation	The process of preparing a solicitation package and selecting a supplier (contractor).

solicitation package

A formal document delineating technical and nontechnical requirements that is used to request offers on invitations for bids (bids) and requests for proposal (proposals), or to request statements of capabilities and price quotations (quotes). It is otherwise used as a basis for selecting a supply source or sources to provide products or services.

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. (See "common cause of process variation.")

specific goal

See Chapter 2 for an explanation of how "specific goal" is used in the CMMI Product Suite. (See "process area," "capability level," "generic goal," "quantitative objective," and "organization's business objectives.")

specific practice

See Chapter 2 for an explanation of how "specific practice" is used in the CMMI Product Suite. (See "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 "special cause of process variation," "common cause of variation," "standard process," "statistically managed process," and "capable process.")

staged representation

A model structure wherein attaining the goals of a set of process areas establishes a maturity level; each level builds a foundation for subsequent levels. (See "process area" and "maturity level.")

stakeholder

See Chapter 3 for an explanation of how "stakeholder" is used in the CMMI Product Suite.

standard

See Chapter 3 for an explanation of how "standard" is used in the CMMI Product Suite.

standard process

An operational definition of the basic process that guides the establishment of a common process in an organization. [ISO/IEC 15504-9]

A standard process 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 Chapter 3 for an explanation of how "defined process" is used in the CMMI Product Suite.)

statement of work	A description of contracted work required to complete a 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 "common cause of process variation," "statistically managed process," 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 process variation are identified, and performance is contained within well-defined limits. (See "stable process," "standard process," "statistical process control," "capable process," and "special cause of process variation.")
strength	As used in CMMI appraisal materials, an exemplary or noteworthy implementation of a CMMI model practice.
subpractice	See Chapter 2 for an explanation of how "subpractice" is used in the CMMI Product Suite.
subprocess	A process that is part of a larger process. (See "process description.")
supplier	(1) An entity delivering products or performing services being acquired. (2) An individual, partnership, company, corporation, association, or other service having an agreement (contract) with an acquirer for the design, development, manufacture, maintenance, modification, or supply of items under the terms of an agreement (contract).
sustainment	The processes used to ensure that a product can be utilized operationally by its end users or customers. Sustainment ensures that maintenance is done such that the product is in an operable condition whether the product is in use or not by customers or end users.

systems engineering

The interdisciplinary approach governing the total technical and managerial effort required to transform a set of customer needs, expectations, and constraints into a product solution and support that solution throughout the product's life.

This includes the definition of technical performance measures, the integration of engineering specialties towards the establishment of a product architecture, and the definition of supporting life-cycle processes that balance cost, performance, and schedule objectives.

tailoring guidelines

See Chapter 3 for an explanation of how "tailoring guidelines" is used in the CMMI Product Suite.

target profile

In the continuous representation, a list of process areas and their corresponding capability levels that represent an objective for process improvement. (See "capability level profile" and "achievement profile.")

target staging

In the continuous representation, a sequence of target profiles that describes the path of process improvement to be followed by the organization. (See "capability level profile," "achievement profile," and "target profile.")

technical data package

A collection of items that may include the following if such information is appropriate to the type of product and product component (for example, material and manufacturing requirements may not be useful for product components associated with software services or processes):

- product architecture description
- allocated requirements
- product-component descriptions
- product-related life-cycle process descriptions if not described as separate product components
- key product characteristics
- required physical characteristics and constraints
- interface requirements
- materials requirements (bills or material and material characteristics)
- fabrication and manufacturing requirements (for both the original equipment manufacturer and field support)
- the verification criteria used to ensure requirements

have been achieved

- conditions of use (environments) and operating/usage scenarios, modes and states for operations, support, training, manufacturing, disposal, and verifications throughout the life of the product
- rationale for decisions and characteristics (requirements, requirement allocations; design choices)

technical requirements

Properties (attributes) of products or services to be acquired or developed.

test procedure

Detailed instructions for the setup, execution, and evaluation of results for a given test.

traceability

(See "requirements traceability.")

trade study

An evaluation of alternatives based on criteria and systematic analysis, to select the best alternative for attaining determined objectives.

training

In the Organizational Training process area, see the definition of "training" in the introductory notes.

typical work product

See Chapter 2 for an explanation of how "typical work product" is used in the CMMI Product Suite.

unit testing

Testing of individual hardware or software units or groups of related units. (See "acceptance testing.")

validation

See Chapter 3 for an explanation of how "validation" is used in the CMMI Product Suite.

verification

See Chapter 3 for an explanation of how "verification" is used in the CMMI Product Suite.

verifying implementation

A common feature of CMMI model process areas with a staged representation that groups the generic practices related to review by higher level management, and objective evaluation of conformance to process descriptions, procedures, and standards.

version control

The establishment and maintenance of baselines and the identification of changes to baselines that make it possible to return to the previous baseline.

weakness

As used in CMMI appraisal materials, the ineffective, or lack of, implementation of one or more CMMI model practices.

work breakdown structure

An arrangement of work elements and their relationship to each other and to the end product.

work product

See Chapter 3 for an explanation of how "work product" is used in the CMMI Product Suite.

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).

D. Required and Expected Model Elements

MATURITY LEVEL: 2

REQUIREMENTS MANAGEMENT

Maturity Level 2

The purpose of Requirements Management is to manage the requirements of the project's products and product components and to identify inconsistencies between those requirements and the project's plans and work products. [PA146]

Specific and Generic Goals

SG 1 Manage Requirements

Requirements are managed and inconsistencies with project plans and work products are identified. *[PA146.IG101]*

GG 2 Institutionalize a Managed Process

The process is institutionalized as a managed process. *[CL103.GL101]*

Practices by Goal:

SG 1 Manage Requirements

Requirements are managed and inconsistencies with project plans and work products are identified. *[PA146.IG101]*

SP 1.1 Obtain an Understanding of Requirements

Develop an understanding with the requirements providers on the meaning of the requirements. *[PA146.IG101.SP101]*

SP 1.2 Obtain Commitment to Requirements

Obtain commitment to the requirements from the project participants. *[PA146.IG101.SP102]*

SP 1.3 Manage Requirements Changes

Manage changes to the requirements as they evolve during the project. *[PA146.IG101.SP103]*

SP 1.4 Maintain Bidirectional Traceability of Requirements

Maintain bidirectional traceability among the requirements and the project plans and work products. *[PA146.IG101.SP104]*

SP 1.5 Identify Inconsistencies between Project Work and Requirements

Identify inconsistencies between the project plans and work products and the requirements. *[PA146.IG101.SP105]*

GG 2 Institutionalize a Managed Process

The process is institutionalized as a managed process. *[CL103.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the requirements management process. *[GP103]*

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the plan for performing the requirements management process. *[GP104]*

GP 2.3 (AB 2) Provide Resources

Provide adequate resources for performing the requirements management process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 3) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the requirements management process. *[GP106]*

GP 2.5 (AB 4) Train People

Train the people performing or supporting the requirements management process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the requirements management process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the requirements management process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the requirements management process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the requirements management process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the requirements management process with higher level management and resolve issues. *[GP112]*

PROJECT PLANNING

Maturity Level 2

The purpose of Project Planning is to establish and maintain plans that define project activities. [PA163]

Specific and Generic Goals

SG 1 Establish Estimates

Estimates of project planning parameters are established and maintained. *[PA163.IG101]*

SG 2 Develop a Project Plan

A project plan is established and maintained as the basis for managing the project. *[PA163.IG102]*

SG 3 Obtain Commitment to the Plan

Commitments to the project plan are established and maintained. *[PA163.IG103]*

GG 2 Institutionalize a Managed Process

The process is institutionalized as a managed process. *[CL103.GL101]*

Practices by Goal:

SG 1 Establish Estimates

Estimates of project planning parameters are established and maintained. *[PA163.IG101]*

SP 1.1 Estimate the Scope of the Project

Establish a top-level work breakdown structure (WBS) to estimate the scope of the project. *[PA163.IG101.SP101]*

SP 1.2 Establish Estimates of Work Product and Task Attributes

Establish and maintain estimates of the attributes of the work products and tasks. *[PA163.IG101.SP102]*

SP 1.3 Define Project Life Cycle

Define the project life-cycle phases upon which to scope the planning effort. *[PA163.IG101.SP103]*

SP 1.4 Determine Estimates of Effort and Cost

Estimate the project effort and cost for the work products and tasks based on estimation rationale. *[PA163.IG101.SP104]*

SG 2 Develop a Project Plan

A project plan is established and maintained as the basis for managing the project. *[PA163.IG102]*

SP 2.1 Establish the Budget and Schedule

Establish and maintain the project's budget and schedule. *[PA163.IG102.SP101]*

SP 2.2 Identify Project Risks

Identify and analyze project risks. *[PA163.IG102.SP103]*

SP 2.3 Plan for Data Management

Plan for the management of project data. *[PA163.IG102.SP102]*

SP 2.4 Plan for Project Resources

Plan for necessary resources to perform the project. *[PA163.IG102.SP104]*

SP 2.5 Plan for Needed Knowledge and Skills

Plan for knowledge and skills needed to perform the project. *[PA163.IG102.SP105]*

SP 2.6 Plan Stakeholder Involvement

Plan the involvement of identified stakeholders. *[PA163.IG102.SP106]*

SP 2.7 Establish the Project Plan

Establish and maintain the overall project plan content.
[PA163.IG102.SP107]

SG 3 Obtain Commitment to the Plan

Commitments to the project plan are established and maintained. *[PA163.IG103]*

SP 3.1 Review Plans that Affect the Project

Review all plans that affect the project to understand project commitments. *[PA163.IG103.SP103]*

SP 3.2 Reconcile Work and Resource Levels

Reconcile the project plan to reflect available and estimated resources. *[PA163.IG103.SP101]*

SP 3.3 Obtain Plan Commitment

Obtain commitment from relevant stakeholders responsible for performing and supporting plan execution. *[PA163.IG103.SP102]*

GG 2 Institutionalize a Managed Process

The process is institutionalized as a managed process. *[CL103.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the project planning process. *[GP103]*

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the plan for performing the project planning process. *[GP104]*

GP 2.3 (AB 2) Provide Resources

Provide adequate resources for performing the project planning process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 3) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the project planning process. *[GP106]*

GP 2.5 (AB 4) Train People

Train the people performing or supporting the project planning process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the project planning process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the project planning process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the project planning process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the project planning process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the project planning process with higher level management and resolve issues. *[GP112]*

PROJECT MONITORING AND CONTROL

Maturity Level 2

The purpose of Project Monitoring and Control is to provide an understanding of the project's progress so that appropriate corrective actions can be taken when the project's performance deviates significantly from the plan. [PA162]

Specific and Generic Goals

SG 1 **Monitor Project Against Plan**

Actual performance and progress of the project are monitored against the project plan. *[PA162.IG101]*

SG 2 **Manage Corrective Action to Closure**

Corrective actions are managed to closure when the project's performance or results deviate significantly from the plan. *[PA162.IG102]*

GG 2 **Institutionalize a Managed Process**

The process is institutionalized as a managed process. *[CL103.GL101]*

Practices by Goal:

SG 1 **Monitor Project Against Plan**

Actual performance and progress of the project are monitored against the project plan. *[PA162.IG101]*

SP 1.1 **Monitor Project Planning Parameters**

Monitor the actual values of the project planning parameters against the project plan. *[PA162.IG101.SP101]*

SP 1.2 **Monitor Commitments**

Monitor commitments against those identified in the project plan. *[PA162.IG101.SP102]*

SP 1.3 Monitor Project Risks

Monitor risks against those identified in the project plan.

[PA162.IG101.SP103]

SP 1.4 Monitor Data Management

Monitor the management of project data against the project plan.

[PA162.IG101.SP106]

SP 1.5 Monitor Stakeholder Involvement

Monitor stakeholder involvement against the project plan.

[PA162.IG101.SP107]

SP 1.6 Conduct Progress Reviews

Periodically review the project's progress, performance, and issues. *[PA162.IG101.SP104]*

SP 1.7 Conduct Milestone Reviews

Review the accomplishments and results of the project at selected project milestones. *[PA162.IG101.SP105]*

SG 2 Manage Corrective Action to Closure

Corrective actions are managed to closure when the project's performance or results deviate significantly from the plan. *[PA162.IG102]*

SP 2.1 Analyze Issues

Collect and analyze the issues and determine the corrective actions necessary to address the issues. *[PA162.IG102.SP101]*

SP 2.2 Take Corrective Action

Take corrective action on identified issues. *[PA162.IG102.SP102]*

SP 2.3 Manage Corrective Action

Manage corrective actions to closure. *[PA162.IG102.SP103]*

GG 2 Institutionalize a Managed Process

The process is institutionalized as a managed process. *[CL103.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the project monitoring and control process. *[GP103]*

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the plan for performing the project monitoring and control process. *[GP104]*

GP 2.3 (AB 2) Provide Resources

Provide adequate resources for performing the project monitoring and control process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 3) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the project monitoring and control process. *[GP106]*

GP 2.5 (AB 4) Train People

Train the people performing or supporting the project monitoring and control process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the project monitoring and control process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the project monitoring and control process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the project monitoring and control process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the project monitoring and control process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the project monitoring and control process with higher level management and resolve issues. *[GP112]*

SUPPLIER AGREEMENT MANAGEMENT

Maturity Level 2

The purpose of Supplier Agreement Management is to manage the acquisition of products from suppliers for which there exists a formal agreement. [PA166]

Specific and Generic Goals

SG 1 Establish Supplier Agreements

Agreements with the suppliers are established and maintained. *[PA166.IG101]*

SG 2 Satisfy Supplier Agreements

Agreements with the suppliers are satisfied by both the project and the supplier. *[PA166:IG102]*

GG 2 Institutionalize a Managed Process

The process is institutionalized as a managed process. *[CL103.GL101]*

Practices by Goal:

SG 1 Establish Supplier Agreements

Agreements with the suppliers are established and maintained. *[PA166.IG101]*

SP 1.1 Determine Acquisition Type

Determine the type of acquisition for each product or product component to be acquired. *[PA166.IG101.SP101]*

SP 1.2 Select Suppliers

Select suppliers based on an evaluation of their ability to meet the specified requirements and established criteria. *[PA166.IG101.SP102]*

SP 1.3 Establish Supplier Agreements

Establish and maintain formal agreements with the supplier.

[PA166.IG101.SP103]

SG 2 Satisfy Supplier Agreements

Agreements with the suppliers are satisfied by both the project and the supplier. *[PA166.IG102]*

SP 2.1 Review COTS Products

Review candidate COTS products to ensure they satisfy the specified requirements that are covered under a supplier agreement. *[PA166.IG102.SP101]*

SP 2.2 Execute the Supplier Agreement

Perform activities with the supplier as specified in the supplier agreement. *[PA166.IG102.SP102]*

SP 2.3 Accept the Acquired Product

Ensure that the supplier agreement is satisfied before accepting the acquired product. *[PA166.IG102.SP103]*

SP 2.4 Transition Products

Transition the acquired products from the supplier to the project.

[PA166.IG102.SP104]

GG 2 Institutionalize a Managed Process

The process is institutionalized as a managed process. *[CL103.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the supplier agreement management process. *[GP103]*

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the plan for performing the supplier agreement management process. *[GP104]*

GP 2.3 (AB 2) Provide Resources

Provide adequate resources for performing the supplier agreement management process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 3) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the supplier agreement management process. *[GP106]*

GP 2.5 (AB 4) Train People

Train the people performing or supporting the supplier agreement management process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the supplier agreement management process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the supplier agreement management process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the supplier agreement management process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the supplier agreement management process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the supplier agreement management process with higher level management and resolve issues. *[GP112]*

MEASUREMENT AND ANALYSIS

Maturity Level 2

The purpose of Measurement and Analysis is to develop and sustain a measurement capability that is used to support management information needs. [PA154]

Specific and Generic Goals

SG 1 Align Measurement and Analysis Activities

Measurement objectives and activities are aligned with identified information needs and objectives. *[PA154.IG101]*

SG 2 Provide Measurement Results

Measurement results that address identified information needs and objectives are provided. *[PA154.IG102]*

GG 2 Institutionalize a Managed Process

The process is institutionalized as a managed process. *[CL103.GL101]*

Practices by Goal:

SG 1 Align Measurement and Analysis Activities

Measurement objectives and activities are aligned with identified information needs and objectives. *[PA154.IG101]*

SP 1.1 Establish Measurement Objectives

Establish and maintain measurement objectives that are derived from identified information needs and objectives. *[PA154.IG101.SP101]*

SP 1.2 Specify Measures

Specify measures to address the measurement objectives.
[PA154.IG101.SP102]

SP 1.3 Specify Data Collection and Storage Procedures

Specify how measurement data will be obtained and stored. *[PA154.IG101.SP103]*

SP 1.4 Specify Analysis Procedures

Specify how measurement data will be analyzed and reported. *[PA154.IG101.SP104]*

SG 2 Provide Measurement Results

Measurement results that address identified information needs and objectives are provided. *[PA154.IG102]*

SP 2.1 Collect Measurement Data

Obtain specified measurement data. *[PA154.IG102.SP101]*

SP 2.2 Analyze Measurement Data

Analyze and interpret measurement data. *[PA154.IG102.SP102]*

SP 2.3 Store Data and Results

Manage and store measurement data, measurement specifications, and analysis results. *[PA154.IG102.SP103]*

SP 2.4 Communicate Results

Report results of measurement and analysis activities to all relevant stakeholders. *[PA154.IG102.SP104]*

GG 2 Institutionalize a Managed Process

The process is institutionalized as a managed process. *[CL103.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the measurement and analysis process. *[GP103]*

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the plan for performing the measurement and analysis process. *[GP104]*

GP 2.3 (AB 2) Provide Resources

Provide adequate resources for performing the measurement and analysis process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 3) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the measurement and analysis process. *[GP106]*

GP 2.5 (AB 4) Train People

Train the people performing or supporting the measurement and analysis process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the measurement and analysis process under appropriate levels of configuration management.
[GP109]

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the measurement and analysis process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the measurement and analysis process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the measurement and analysis process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the measurement and analysis process with higher level management and resolve issues. *[GP112]*

PROCESS AND PRODUCT QUALITY ASSURANCE

Maturity Level 2

The purpose of Process and Product Quality Assurance is to provide staff and management with objective insight into processes and associated work products. [PA145]

Specific and Generic Goals

SG 1 **Objectively Evaluate Processes and Work Products**

Adherence of the performed process and associated work products and services to applicable process descriptions, standards, and procedures is objectively evaluated. *[PA145.IG101]*

SG 2 **Provide Objective Insight**

Noncompliance issues are objectively tracked and communicated, and resolution is ensured. *[PA145.IG102]*

GG 2 **Institutionalize a Managed Process**

The process is institutionalized as a managed process. *[CL103.GL101]*

Practices by Goal:

SG 1 **Objectively Evaluate Processes and Work Products**

Adherence of the performed process and associated work products and services to applicable process descriptions, standards, and procedures is objectively evaluated. *[PA145.IG101]*

SP 1.1 **Objectively Evaluate Processes**

Objectively evaluate the designated performed processes against the applicable process descriptions, standards, and procedures.

[PA145.IG101.SP101]

SP 1.2 **Objectively Evaluate Work Products and Services**

Objectively evaluate the designated work products and services against the applicable process descriptions, standards, and procedures. *[PA145.IG101.SP102]*

SG 2 Provide Objective Insight

Noncompliance issues are objectively tracked and communicated, and resolution is ensured. *[PA145.IG102]*

SP 2.1 Communicate and Ensure Resolution of Noncompliance Issues

Communicate quality issues and ensure resolution of noncompliance issues with the staff and managers. *[PA145.IG102.SP101]*

SP 2.2 Establish Records

Establish and maintain records of the quality assurance activities.

[PA145.IG102.SP102]

GG 2 Institutionalize a Managed Process

The process is institutionalized as a managed process. *[CL103.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the process and product quality assurance process.

[GP103]

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the plan for performing the process and product quality assurance process. *[GP104]*

GP 2.3 (AB 2) Provide Resources

Provide adequate resources for performing the process and product quality assurance process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 3) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the process and product quality assurance process. *[GP106]*

GP 2.5 (AB 4) Train People

Train the people performing or supporting the process and product quality assurance process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the process and product quality assurance process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the process and product quality assurance process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the process and product quality assurance process against the plan for performing the process and take appropriate corrective action. *[GP110]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the process and product quality assurance process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the process and product quality assurance process with higher level management and resolve issues. *[GP112]*

CONFIGURATION MANAGEMENT

Maturity Level 2

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. [PA159]

Specific and Generic Goals

SG 1 **Establish Baselines**

Baselines of identified work products are established. *[PA159.IG101]*

SG 2 **Track and Control Changes**

Changes to the work products under configuration management are tracked and controlled. *[PA159.IG102]*

SG 3 **Establish Integrity**

Integrity of baselines is established and maintained. *[PA159.IG103]*

GG 2 **Institutionalize a Managed Process**

The process is institutionalized as a managed process. *[CL103.GL101]*

Practices by Goal:

SG 1 **Establish Baselines**

Baselines of identified work products are established. *[PA159.IG101]*

SP 1.1 **Identify Configuration Items**

Identify the configuration items, components, and related work products that will be placed under configuration management.
[PA159.IG101.SP101]

SP 1.2 **Establish a Configuration Management System**

Establish and maintain a configuration management and change management system for controlling work products. *[PA159.IG101.SP102]*

SP 1.3 Create or Release Baselines

Create or release baselines for internal use and for delivery to the customer. *[PA159.IG101.SP103]*

SG 2 Track and Control Changes

Changes to the work products under configuration management are tracked and controlled. *[PA159.IG102]*

SP 2.1 Track Change Requests

Track change requests for the configuration items. *[PA159.IG102.SP101]*

SP 2.2 Control Configuration Items

Control changes to the configuration items. *[PA159.IG102.SP102]*

SG 3 Establish Integrity

Integrity of baselines is established and maintained. *[PA159.IG103]*

SP 3.1 Establish Configuration Management Records

Establish and maintain records describing configuration items. *[PA159.IG103.SP101]*

SP 3.2 Perform Configuration Audits

Perform configuration audits to maintain integrity of the configuration baselines. *[PA159.IG103.SP102]*

GG 2 Institutionalize a Managed Process

The process is institutionalized as a managed process. *[CL103.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the configuration management process. *[GP103]*

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the plan for performing the configuration management process. *[GP104]*

GP 2.3 (AB 2) Provide Resources

Provide adequate resources for performing the configuration management process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 3) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the configuration management process. *[GP106]*

GP 2.5 (AB 4) Train People

Train the people performing or supporting the configuration management process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the configuration management process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the configuration management process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the configuration management process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the configuration management process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the configuration management process with higher level management and resolve issues. *[GP112]*

MATURITY LEVEL: 3

REQUIREMENTS DEVELOPMENT

Maturity Level 3

The purpose of Requirements Development is to produce and analyze customer, product, and product-component requirements. [PA157]

Specific and Generic Goals

SG 1 **Develop Customer Requirements**

Stakeholder needs, expectations, constraints, and interfaces are collected and translated into customer requirements. *[PA157.IG101]*

SG 2 **Develop Product Requirements**

Customer requirements are refined and elaborated to develop product and product-component requirements. *[PA157.IG103]*

SG 3 **Analyze and Validate Requirements**

The requirements are analyzed and validated, and a definition of required functionality is developed. *[PA157.IG102]*

GG 3 **Institutionalize a Defined Process**

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 **Develop Customer Requirements**

Stakeholder needs, expectations, constraints, and interfaces are collected and translated into customer requirements. *[PA157.IG101]*

SP 1.1 **Elicit Needs**

Elicit stakeholder needs, expectations, constraints, and interfaces for all phases of the product life cycle. *[PA157.IG101.SP102]*

The following specific practice appears in the continuous representation as SP 1.1-1, but is subsumed in the staged representation by SP 1.1, Elicit Needs. The specific practice is presented here in gray only as informative material.

SP 1.1-1 Collect Stakeholder Needs

Identify and collect stakeholder needs, expectations, constraints, and interfaces for all phases of the product life cycle. [PA157.IG101.SP101]

SP 1.2 Develop the Customer Requirements

Transform stakeholder needs, expectations, constraints, and interfaces into customer requirements. [PA157.IG101.SP103]

SG 2 Develop Product Requirements

Customer requirements are refined and elaborated to develop product and product-component requirements. [PA157.IG103]

SP 2.1 Establish Product and Product-Component Requirements

Establish and maintain product and product-component requirements, which are based on the customer requirements.

[PA157.IG103.SP101]

SP 2.2 Allocate Product-Component Requirements

Allocate the requirements for each product component.

[PA157.IG103.SP102]

SP 2.3 Identify Interface Requirements

Identify interface requirements. [PA157.IG103.SP103]

SG 3 Analyze and Validate Requirements

The requirements are analyzed and validated, and a definition of required functionality is developed. [PA157.IG102]

SP 3.1 Establish Operational Concepts and Scenarios

Establish and maintain operational concepts and associated scenarios. [PA157.IG102.SP101]

SP 3.2 Establish a Definition of Required Functionality

Establish and maintain a definition of required functionality. *[PA157.IG102.SP102]*

SP 3.3 Analyze Requirements

Analyze requirements to ensure that they are necessary and sufficient. *[PA157.IG102.SP103]*

SP 3.4 Analyze Requirements to Achieve Balance

Analyze requirements to balance stakeholder needs and constraints. *[PA157.IG102.SP104]*

SP 3.5 Validate Requirements with Comprehensive Methods

Validate requirements to ensure the resulting product will perform as intended in the user's environment using multiple techniques as appropriate. *[PA157.IG102.SP106]*

The following specific practice appears in the continuous representation as SP 3.5-1, but is subsumed in the staged representation by SP 3.5, Validate Requirements with Comprehensive Methods. The specific practice is presented here in gray only as informative material.

SP 3.5-1 Validate Requirements

Validate requirements to ensure the resulting product will perform appropriately in its intended-use environment. *[PA157.IG102.SP105]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the requirements development process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined requirements development process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the requirements development process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the requirements development process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the requirements development process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the requirements development process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

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

[GP109]

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the requirements development process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the requirements development process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the requirements development process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the requirements development process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the requirements development process with higher level management and resolve issues. *[GP112]*

TECHNICAL SOLUTION

Maturity Level 3

The purpose of Technical Solution is to design, develop, and implement solutions to requirements. Solutions, designs, and implementations encompass products, product components, and product-related life-cycle processes either singly or in combinations as appropriate. [PA160]

Specific and Generic Goals

SG 1 **Select Product-Component Solutions**

Product or product-component solutions are selected from alternative solutions. *[PA160.IG101]*

SG 2 **Develop the Design**

Product or product-component designs are developed. *[PA160.IG102]*

SG 3 **Implement the Product Design**

Product components, and associated support documentation, are implemented from their designs. *[PA160.IG103]*

GG 3 **Institutionalize a Defined Process**

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 **Select Product-Component Solutions**

Product or product-component solutions are selected from alternative solutions. *[PA160.IG101]*

SP 1.1 **Develop Detailed Alternative Solutions and Selection Criteria**

Develop detailed alternative solutions and selection criteria.

[PA160.IG101.SP102]

The following specific practice appears in the continuous representation as SP 1.1-1, but is subsumed in the staged representation by SP 1.1, Develop Detailed Alternative Solutions and Selection Criteria. The specific practice is presented here in gray only as informative material.

SP 1.1-1 Develop Alternative Solutions and Selection Criteria

Develop alternative solutions and selection criteria. [PA160.IG101.SP101]

SP 1.2 Evolve Operational Concepts and Scenarios

Evolve the operational concept, scenarios, and environments to describe the conditions, operating modes, and operating states specific to each product component. [PA160.IG101.SP103]

SP 1.3 Select Product-Component Solutions

Select the product-component solutions that best satisfy the criteria established. [PA160.IG101.SP104]

SG 2 Develop the Design

Product or product-component designs are developed. [PA160.IG102]

SP 2.1 Design the Product or Product Component

Develop a design for the product or product component.
[PA160.IG102.SP101]

SP 2.2 Establish a Technical Data Package

Establish and maintain a technical data package. [PA160.IG102.SP103]

SP 2.3 Design Interfaces Using Criteria

Design comprehensive product-component interfaces in terms of established and maintained criteria. [PA160.IG102.SP105]

The following specific practice appears in the continuous representation as SP 2.3-1, but is subsumed in the staged representation by SP 2.3, Design Interfaces Using Criteria. The specific practice is presented here in gray only as informative material.

SP 2.3-1 Establish Interface Descriptions

Establish and maintain the solution for product-component interfaces. [PA160.IG102.SP104]

SP 2.4 Perform Make, Buy, or Reuse Analyses

Evaluate whether the product components should be developed, purchased, or reused based on established criteria. [PA160.IG102.SP106]

SG 3 Implement the Product Design

Product components, and associated support documentation, are implemented from their designs. [PA160.IG103]

SP 3.1 Implement the Design

Implement the designs of the product components. [PA160.IG103.SP101]

SP 3.2 Develop Product Support Documentation

Develop and maintain the end-use documentation. [PA160.IG103.SP102]

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. [CL104.GL101]

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the technical solution process. [GP103]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined technical solution process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the technical solution process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the technical solution process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the technical solution process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the technical solution process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the technical solution process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the technical solution process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the technical solution process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

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

[GP117]

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the technical solution process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the technical solution process with higher level management and resolve issues. *[GP112]*

PRODUCT INTEGRATION

Maturity Level 3

The purpose of Product Integration is to assemble the product from the product components, ensure that the product, as integrated, functions properly, and deliver the product. [PA147]

Specific and Generic Goals

SG 1 **Prepare for Product Integration**

Preparation for product integration is conducted. *[PA147.IG101]*

SG 2 **Ensure Interface Compatibility**

The product-component interfaces, both internal and external, are compatible. *[PA147.IG102]*

SG 3 **Assemble Product Components and Deliver the Product**

Verified product components are assembled and the integrated, verified, and validated product is delivered. *[PA147.IG103]*

GG 3 **Institutionalize a Defined Process**

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 **Prepare for Product Integration**

Preparation for product integration is conducted. *[PA147.IG101]*

SP 1.1 **Determine Integration Sequence**

Determine the product-component integration sequence.

[PA147.IG101.SP101]

SP 1.2 **Establish the Product Integration Environment**

Establish and maintain the environment needed to support the integration of the product components. *[PA147.IG101.SP102]*

SP 1.3 Establish Product Integration Procedures and Criteria

Establish and maintain procedures and criteria for integration of the product components. *[PA147.IG101.SP103]*

SG 2 Ensure Interface Compatibility

The product-component interfaces, both internal and external, are compatible. *[PA147.IG102]*

SP 2.1 Review Interface Descriptions for Completeness

Review interface descriptions for coverage and completeness. *[PA147.IG102.SP101]*

SP 2.2 Manage Interfaces

Manage internal and external interface definitions, designs, and changes for products and product components. *[PA147.IG102.SP102]*

SG 3 Assemble Product Components and Deliver the Product

Verified product components are assembled and the integrated, verified, and validated product is delivered. *[PA147.IG103]*

SP 3.1 Confirm Readiness of Product Components for Integration

Confirm, prior to assembly, that each product component required to assemble the product has been properly identified, functions according to its description, and that the product-component interfaces comply with the interface descriptions. *[PA147.IG103.SP101]*

SP 3.2 Assemble Product Components

Assemble product components according to the product integration sequence and available procedures. *[PA147.IG103.SP102]*

SP 3.3 Evaluate Assembled Product Components

Evaluate assembled product components for interface compatibility. *[PA147.IG103.SP103]*

SP 3.4 Package and Deliver the Product or Product Component

Package the assembled product or product component and deliver it to the appropriate customer. *[PA147.IG103.SP104]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the product integration process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined product integration process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the product integration process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the product integration process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the product integration process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the product integration process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

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

[GP109]

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the product integration process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the product integration process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

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

[GP117]

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the product integration process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the product integration process with higher level management and resolve issues. *[GP112]*

VERIFICATION

Maturity Level 3

The purpose of Verification is to ensure that selected work products meet their specified requirements. [PA150]

Specific and Generic Goals

SG 1 **Prepare for Verification**

Preparation for verification is conducted. *[PA150.IG101]*

SG 2 **Perform Peer Reviews**

Peer reviews are performed on selected work products. *[PA150.IG102]*

SG 3 **Verify Selected Work Products**

Selected work products are verified against their specified requirements. *[PA150.IG103]*

GG 3 **Institutionalize a Defined Process**

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 **Prepare for Verification**

Preparation for verification is conducted. *[PA150.IG101]*

SP 1.1 **Select Work Products for Verification**

Select the work products to be verified and the verification methods that will be used for each. *[PA150.IG101.SP101]*

SP 1.2 **Establish the Verification Environment**

Establish and maintain the environment needed to support verification. *[PA150.IG101.SP102]*

SP 1.3 Establish Verification Procedures and Criteria

Establish and maintain verification procedures and criteria for the selected work products. *[PA150.IG101.SP103]*

SG 2 Perform Peer Reviews

Peer reviews are performed on selected work products. *[PA150.IG102]*

SP 2.1 Prepare for Peer Reviews

Prepare for peer reviews of selected work products. *[PA150.IG102.SP101]*

SP 2.2 Conduct Peer Reviews

Conduct peer reviews on selected work products and identify issues resulting from the peer review. *[PA150.IG102.SP102]*

SP 2.3 Analyze Peer Review Data

Analyze data about preparation, conduct, and results of the peer reviews. *[PA150.IG102.SP103]*

SG 3 Verify Selected Work Products

Selected work products are verified against their specified requirements. *[PA150.IG103]*

SP 3.1 Perform Verification

Perform verification on the selected work products. *[PA150.IG103.SP101]*

SP 3.2 Analyze Verification Results and Identify Corrective Action

Analyze the results of all verification activities and identify corrective action. *[PA150.IG103.SP102]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the verification process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined verification process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the verification process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the verification process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the verification process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the verification process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the verification process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the verification process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the verification process against the plan for performing the process and take appropriate corrective action.
[GP110]

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the verification process to support the future use and improvement of the organization's processes and process assets.
[GP117]

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the verification process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the verification process with higher level management and resolve issues. *[GP112]*

VALIDATION

Maturity Level 3

The purpose of Validation is to demonstrate that a product or product component fulfills its intended use when placed in its intended environment. [PA149]

Specific and Generic Goals

SG 1 Prepare for Validation

Preparation for validation is conducted. *[PA149.IG101]*

SG 2 Validate Product or Product Components

The product or product components are validated to ensure that they are suitable for use in their intended operating environment. *[PA149.IG102]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 Prepare for Validation

Preparation for validation is conducted. *[PA149.IG101]*

SP 1.1 Select Products for Validation

Select products and product components to be validated and the validation methods that will be used for each. *[PA149.IG101.SP101]*

SP 1.2 Establish the Validation Environment

Establish and maintain the environment needed to support validation. *[PA149.IG101.SP102]*

SP 1.3 Establish Validation Procedures and Criteria

Establish and maintain procedures and criteria for validation.

[PA149.IG101.SP103]

SG 2 Validate Product or Product Components

The product or product components are validated to ensure that they are suitable for use in their intended operating environment. *[PA149.IG102]*

SP 2.1 Perform Validation

Perform validation on the selected products and product components. *[PA149.IG102.SP101]*

SP 2.2 Analyze Validation Results

Analyze the results of the validation activities and identify issues. *[PA149.IG102.SP102]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the validation process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined validation process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the validation process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the validation process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the validation process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the validation process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the validation process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the validation process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the validation process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the validation process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the validation process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the validation process with higher level management and resolve issues. *[GP112]*

ORGANIZATIONAL PROCESS FOCUS

Maturity Level 3

The purpose of Organizational Process Focus is to plan and implement organizational process improvement based on a thorough understanding of the current strengths and weaknesses of the organization's processes and process assets. [PA152]

Specific and Generic Goals

SG 1 **Determine Process-Improvement Opportunities**

Strengths, weaknesses, and improvement opportunities for the organization's processes are identified periodically and as needed. *[PA152.IG101]*

SG 2 **Plan and Implement Process-Improvement Activities**

Improvements are planned and implemented, organizational process assets are deployed, and process-related experiences are incorporated into the organizational process assets. *[PA152.IG102]*

GG 3 **Institutionalize a Defined Process**

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 **Determine Process-Improvement Opportunities**

Strengths, weaknesses, and improvement opportunities for the organization's processes are identified periodically and as needed. *[PA152.IG101]*

SP 1.1 **Establish Organizational Process Needs**

Establish and maintain the description of the process needs and objectives for the organization. *[PA152.IG101.SP101]*

SP 1.2 **Appraise the Organization's Processes**

Appraise the processes of the organization periodically and as needed to maintain an understanding of their strengths and weaknesses. *[PA152.IG101.SP102]*

SP 1.3 Identify the Organization's Process Improvements

Identify improvements to the organization's processes and process assets. *[PA152.IG101.SP103]*

SG 2 Plan and Implement Process-Improvement Activities

Improvements are planned and implemented, organizational process assets are deployed, and process-related experiences are incorporated into the organizational process assets. *[PA152.IG102]*

SP 2.1 Establish Process Action Plans

Establish and maintain process action plans to address improvements to the organization's processes and process assets. *[PA152.IG102.SP101]*

SP 2.2 Implement Process Action Plans

Implement process action plans across the organization.
[PA152.IG102.SP102]

SP 2.3 Deploy Organizational Process Assets

Deploy organizational process assets across the organization.
[PA152.IG102.SP103]

SP 2.4 Incorporate Process-Related Experiences into the Organizational Process Assets

Incorporate process-related work products, measures, and improvement information derived from planning and performing the process into the organizational process assets. *[PA152.IG102.SP104]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the organizational process focus process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined organizational process focus process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the organizational process focus process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the organizational process focus process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the organizational process focus process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the organizational process focus process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the organizational process focus process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the organizational process focus process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the organizational process focus process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the organizational process focus process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational process focus process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the organizational process focus process with higher level management and resolve issues. *[GP112]*

ORGANIZATIONAL PROCESS DEFINITION

Maturity Level 3

The purpose of Organizational Process Definition is to establish and maintain a usable set of organizational process assets. [PA153]

Specific and Generic Goals

SG 1 Establish Organizational Process Assets

A set of organizational process assets is established and maintained. *[PA153.IG101]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 Establish Organizational Process Assets

A set of organizational process assets is established and maintained. *[PA153.IG101]*

SP 1.1 Establish Standard Processes

Establish and maintain the organization's set of standard processes. *[PA153.IG101.SP101]*

SP 1.2 Establish Life-Cycle Model Descriptions

Establish and maintain descriptions of the life-cycle models approved for use in the organization. *[PA153.IG101.SP102]*

SP 1.3 Establish Tailoring Criteria and Guidelines

Establish and maintain the tailoring criteria and guidelines for the organization's set of standard processes. *[PA153.IG101.SP103]*

SP 1.4 Establish the Organization's Measurement Repository

Establish and maintain the organization's measurement repository. *[PA153.IG101.SP104]*

SP 1.5 Establish the Organization's Process Asset Library

Establish and maintain the organization's process asset library. *[PA153.IG101.SP105]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the organizational process definition process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined organizational process definition process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the organizational process definition process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the organizational process definition process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the organizational process definition process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the organizational process definition process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the organizational process definition process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the organizational process definition process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the organizational process definition process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the organizational process definition process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational process definition process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the organizational process definition process with higher level management and resolve issues. *[GP112]*

ORGANIZATIONAL TRAINING

Maturity Level 3

The purpose of Organizational Training is to develop the skills and knowledge of people so they can perform their roles effectively and efficiently. [PA158]

Specific and Generic Goals

SG 1 **Establish an Organizational Training Capability**

A training capability that supports the organization's management and technical roles is established and maintained. *[PA158.IG101]*

SG 2 **Provide Necessary Training**

Training necessary for individuals to perform their roles effectively is provided. *[PA158.IG102]*

GG 3 **Institutionalize a Defined Process**

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 **Establish an Organizational Training Capability**

A training capability that supports the organization's management and technical roles is established and maintained. *[PA158.IG101]*

SP 1.1 **Establish the Strategic Training Needs**

Establish and maintain the strategic training needs of the organization. *[PA158.IG101.SP101]*

SP 1.2 **Determine Which Training Needs Are the Responsibility of the Organization**

Determine which training needs are the responsibility of the organization and which will be left to the individual project or support group. *[PA158.IG101.SP102]*

SP 1.3 Establish an Organizational Training Tactical Plan

Establish and maintain an organizational training tactical plan. *[PA158.IG101.SP103]*

SP 1.4 Establish Training Capability

Establish and maintain training capability to address organizational training needs. *[PA158.IG101.SP104]*

SG 2 Provide Necessary Training

Training necessary for individuals to perform their roles effectively is provided. *[PA158.IG102]*

SP 2.1 Deliver Training

Deliver the training following the organizational training tactical plan. *[PA158.IG102.SP101]*

SP 2.2 Establish Training Records

Establish and maintain records of the organizational training. *[PA158.IG102.SP102]*

SP 2.3 Assess Training Effectiveness

Assess the effectiveness of the organization's training program. *[PA158.IG102.SP103]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the organizational training process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined organizational training process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the organizational training process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the organizational training process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the organizational training process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the organizational training process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

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

[GP109]

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the organizational training process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the organizational training process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

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

[GP117]

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational training process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the organizational training process with higher level management and resolve issues.

[GP112]

INTEGRATED PROJECT MANAGEMENT FOR IPPD

Maturity Level 3

The purpose of Integrated Project Management is to establish and manage the project and the involvement of the relevant stakeholders according to an integrated and defined process that is tailored from the organization's set of standard processes. [PA167]

For Integrated Product and Process Development, Integrated Project Management also covers the establishment of a shared vision for the project and a team structure for integrated teams that will carry out the objectives of the project. [PA167.PE101]

Specific and Generic Goals

SG 1 **Use the Project's Defined Process**

The project is conducted using a defined process that is tailored from the organization's set of standard processes. *[PA167.IG101]*

SG 2 **Coordinate and Collaborate with Relevant Stakeholders**

Coordination and collaboration of the project with relevant stakeholders is conducted. *[PA167.IG102]*

SG 3 **Use the Project's Shared Vision for IPPD**

The project is conducted using the project's shared vision. *[PA167.IG103]*

SG 4 **Organize Integrated Teams for IPPD**

The integrated teams needed to execute the project are identified, defined, structured, and tasked. *[PA167.IG104]*

GG 3 **Institutionalize a Defined Process**

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 **Use the Project's Defined Process**

The project is conducted using a defined process that is tailored from the organization's set of standard processes. *[PA167.IG101]*

SP 1.1 Establish the Project's Defined Process

Establish and maintain the project's defined process. *[PA167.IG101.SP101]*

SP 1.2 Use Organizational Process Assets for Planning Project Activities

Use the organizational process assets and measurement repository for estimating and planning the project's activities. *[PA167.IG101.SP102]*

SP 1.3 Integrate Plans

Integrate the project plan and the other plans that affect the project to describe the project's defined process. *[PA167.IG101.SP103]*

SP 1.4 Manage the Project Using the Integrated Plans

Manage the project using the project plan, the other plans that affect the project, and the project's defined process. *[PA167.IG101.SP104]*

SP 1.5 Contribute to the Organizational Process Assets

Contribute work products, measures, and documented experiences to the organizational process assets. *[PA167.IG101.SP105]*

SG 2 Coordinate and Collaborate with Relevant Stakeholders

Coordination and collaboration of the project with relevant stakeholders is conducted. *[PA167.IG102]*

SP 2.1 Manage Stakeholder Involvement

Manage the involvement of the relevant stakeholders in the project. *[PA167.IG102.SP101]*

SP 2.2 Manage Dependencies

Participate with relevant stakeholders to identify, negotiate, and track critical dependencies. *[PA167.IG102.SP102]*

SP 2.3 Resolve Coordination Issues

Resolve issues with relevant stakeholders. *[PA167.IG102.SP103]*

SG 3 Use the Project's Shared Vision for IPPD

The project is conducted using the project's shared vision. *[PA167.IG103]*

SP 3.1 Define Project's Shared-Vision Context

Identify expectations, constraints, interfaces, and operational conditions applicable to the project's shared vision. *[PA167.IG103.SP101]*

SP 3.2 Establish the Project's Shared Vision

Establish and maintain a shared vision for the project. *[PA167.IG103.SP102]*

SG 4 Organize Integrated Teams for IPPD

The integrated teams needed to execute the project are identified, defined, structured, and tasked. *[PA167.IG104]*

SP 4.1 Determine Integrated Team Structure for the Project

Determine the integrated team structure that will best meet the project objectives and constraints. *[PA167.IG104.SP101]*

SP 4.2 Develop a Preliminary Distribution of Requirements to Integrated Teams

Develop a preliminary distribution of requirements, responsibilities, authorities, tasks, and interfaces to teams in the selected integrated team structure. *[PA167.IG104.SP102]*

SP 4.3 Establish Integrated Teams

Establish and maintain teams in the integrated team structure. *[PA167.IG104.SP103]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the integrated project management process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined integrated project management process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the integrated project management process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the integrated project management process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the integrated project management process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the integrated project management process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the integrated project management process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the integrated project management process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the integrated project management process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the integrated project management process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the integrated project management process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the integrated project management process with higher level management and resolve issues. *[GP112]*

RISK MANAGEMENT

Maturity Level 3

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 across the life of the product or project to mitigate adverse impacts on achieving objectives. [PA148]

Specific and Generic Goals

SG 1 **Prepare for Risk Management**

Preparation for risk management is conducted. *[PA148.IG101]*

SG 2 **Identify and Analyze Risks**

Risks are identified and analyzed to determine their relative importance. *[PA148.IG102]*

SG 3 **Mitigate Risks**

Risks are handled and mitigated, where appropriate, to reduce adverse impacts on achieving objectives. *[PA148.IG103]*

GG 3 **Institutionalize a Defined Process**

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 **Prepare for Risk Management**

Preparation for risk management is conducted. *[PA148.IG101]*

SP 1.1 **Determine Risk Sources and Categories**

Determine risk sources and categories. *[PA148.IG101.SP101]*

SP 1.2 **Define Risk Parameters**

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

[PA148.IG101.SP102]

SP 1.3 Establish a Risk Management Strategy

Establish and maintain the strategy to be used for risk management. *[PA148.IG101.SP103]*

SG 2 Identify and Analyze Risks

Risks are identified and analyzed to determine their relative importance. *[PA148.IG102]*

SP 2.1 Identify Risks

Identify and document the risks. *[PA148.IG102.SP101]*

SP 2.2 Evaluate, Categorize, and Prioritize Risks

Evaluate and categorize each identified risk using the defined risk categories and parameters, and determine its relative priority. *[PA148.IG102.SP102]*

SG 3 Mitigate Risks

Risks are handled and mitigated, where appropriate, to reduce adverse impacts on achieving objectives. *[PA148.IG103]*

SP 3.1 Develop Risk Mitigation Plans

Develop a risk mitigation plan for the most important risks to the project, as defined by the risk management strategy. *[PA148.IG103.SP101]*

SP 3.2 Implement Risk Mitigation Plans

Monitor the status of each risk periodically and implement the risk mitigation plan as appropriate. *[PA148.IG103.SP102]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the risk management process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined risk management process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the risk management process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the risk management process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the risk management process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the risk management process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the risk management process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the risk management process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the risk management process against the plan for performing the process and take appropriate corrective action.

[GP110]

GP 3.2 (DI 4) Collect Improvement Information

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

[GP117]

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the risk management process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the risk management process with higher level management and resolve issues. *[GP112]*

INTEGRATED TEAMING

Maturity Level 3

The purpose of Integrated Teaming is to form and sustain an integrated team for the development of work products. [PA170]

Specific and Generic Goals

SG 1 **Establish Team Composition**

A team composition that provides the knowledge and skills required to deliver the team's product is established and maintained. *[PA170.IG101]*

SG 2 **Govern Team Operation**

Operation of the integrated team is governed according to established principles. *[PA170.IG102]*

GG 3 **Institutionalize a Defined Process**

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 **Establish Team Composition**

A team composition that provides the knowledge and skills required to deliver the team's product is established and maintained. *[PA170.IG101]*

SP 1.1 **Identify Team Tasks**

Identify and define the team's specific internal tasks to generate the team's expected output. *[PA170.IG101.SP101]*

SP 1.2 **Identify Needed Knowledge and Skills**

Identify the knowledge, skills, and functional expertise needed to perform team tasks. *[PA170.IG101.SP102]*

SP 1.3 **Assign Appropriate Team Members**

Assign the appropriate personnel to be team members based on required knowledge and skills. *[PA170.IG101.SP103]*

SG 2 Govern Team Operation

Operation of the integrated team is governed according to established principles. *[PA170.IG102]*

SP 2.1 Establish a Shared Vision

Establish and maintain a shared vision for the integrated team that is aligned with any overarching or higher level vision. *[PA170.IG102.SP101]*

SP 2.2 Establish a Team Charter

Establish and maintain a team charter based on the integrated team's shared vision and overall team objectives. *[PA170.IG102.SP102]*

SP 2.3 Define Roles and Responsibilities

Clearly define and maintain each team member's roles and responsibilities. *[PA170.IG102.SP103]*

SP 2.4 Establish Operating Procedures

Establish and maintain integrated team operating procedures. *[PA170.IG102.SP104]*

SP 2.5 Collaborate among Interfacing Teams

Establish and maintain collaboration among interfacing teams. *[PA170.IG102.SP105]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the integrated teaming process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined integrated teaming process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the integrated teaming process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the integrated teaming process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the integrated teaming process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the integrated teaming process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the integrated teaming process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the integrated teaming process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the integrated teaming process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

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

[GP117]

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the integrated teaming process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the integrated teaming process with higher level management and resolve issues. *[GP112]*

DECISION ANALYSIS AND RESOLUTION

Maturity Level 3

The purpose of Decision Analysis and Resolution is to analyze possible decisions using a formal evaluation process that evaluates identified alternatives against established criteria. [PA156]

Specific and Generic Goals

SG 1 Evaluate Alternatives

Decisions are based on an evaluation of alternatives using established criteria. *[PA156.IG101]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 Evaluate Alternatives

Decisions are based on an evaluation of alternatives using established criteria. *[PA156.IG101]*

SP 1.1 Establish Guidelines for Decision Analysis

Establish and maintain guidelines to determine which issues are subject to a formal evaluation process. *[PA156.IG101.SP101]*

SP 1.2 Establish Evaluation Criteria

Establish and maintain the criteria for evaluating alternatives, and the relative ranking of these criteria. *[PA156.IG101.SP103]*

SP 1.3 Identify Alternative Solutions

Identify alternative solutions to address issues. *[PA156.IG101.SP104]*

SP 1.4 Select Evaluation Methods

Select the evaluation methods. *[PA156.IG101.SP102]*

SP 1.5 Evaluate Alternatives

Evaluate alternative solutions using the established criteria and methods. *[PA156.IG101.SP105]*

SP 1.6 Select Solutions

Select solutions from the alternatives based on the evaluation criteria. *[PA156.IG101.SP106]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the decision analysis and resolution process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined decision analysis and resolution process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the decision analysis and resolution process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the decision analysis and resolution process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the decision analysis and resolution process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the decision analysis and resolution process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the decision analysis and resolution process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the decision analysis and resolution process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the decision analysis and resolution process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the decision analysis and resolution process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the decision analysis and resolution process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the decision analysis and resolution process with higher level management and resolve issues. *[GP112]*

ORGANIZATIONAL ENVIRONMENT FOR INTEGRATION

Maturity Level 3

The purpose of Organizational Environment for Integration is to provide an Integrated Product and Process Development (IPPD) infrastructure and manage people for integration. [PA169]

Specific and Generic Goals

SG 1 **Provide IPPD Infrastructure**

An infrastructure that maximizes the productivity of people and affects the collaboration necessary for integration is provided. *[PA169.IG101]*

SG 2 **Manage People for Integration**

People are managed to nurture the integrative and collaborative behaviors of an IPPD environment. *[PA169.IG102]*

GG 3 **Institutionalize a Defined Process**

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 **Provide IPPD Infrastructure**

An infrastructure that maximizes the productivity of people and affects the collaboration necessary for integration is provided. *[PA169.IG101]*

SP 1.1 **Establish the Organization's Shared Vision**

Establish and maintain a shared vision for the organization.

[PA169.IG101.SP101]

SP 1.2 **Establish an Integrated Work Environment**

Establish and maintain an integrated work environment that supports IPPD by enabling collaboration and concurrent development. *[PA169.IG101.SP102]*

SP 1.3 Identify IPPD-Unique Skill Requirements

Identify the unique skills needed to support the IPPD environment. *[PA169.IG101.SP103]*

SG 2 Manage People for Integration

People are managed to nurture the integrative and collaborative behaviors of an IPPD environment. *[PA169.IG102]*

SP 2.1 Establish Leadership Mechanisms

Establish and maintain leadership mechanisms to enable timely collaboration. *[PA169.IG102.SP101]*

SP 2.2 Establish Incentives for Integration

Establish and maintain incentives for adopting and demonstrating integrative and collaborative behaviors at all levels of the organization. *[PA169.IG102.SP102]*

SP 2.3 Establish Mechanisms to Balance Team and Home Organization Responsibilities

Establish and maintain organizational guidelines to balance team and home organization responsibilities. *[PA169.IG102.SP103]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the organizational environment for integration process.

[GP103]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined organizational environment for integration process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the organizational environment for integration process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the organizational environment for integration process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the organizational environment for integration process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the organizational environment for integration process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the organizational environment for integration process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the organizational environment for integration process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the organizational environment for integration process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the organizational environment for integration process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational environment for integration process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the organizational environment for integration process with higher level management and resolve issues. *[GP112]*

MATURITY LEVEL: 4

ORGANIZATIONAL PROCESS PERFORMANCE

Maturity Level 4

The purpose of Organizational Process Performance is to establish and maintain a quantitative understanding of the performance of the organization's set of standard processes in support of quality and process-performance objectives, and to provide the process performance data, baselines, and models to quantitatively manage the organization's projects. [PA164]

Specific and Generic Goals

SG 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. *[PA164.IG101]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 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. *[PA164.IG101]*

SP 1.1 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. *[PA164.IG101.SP101]*

SP 1.2 Establish Process Performance Measures

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

[PA164.IG101.SP102]

SP 1.3 Establish Quality and Process-Performance Objectives

Establish and maintain quantitative objectives for quality and process performance for the organization. *[PA164.IG101.SP103]*

SP 1.4 Establish Process Performance Baselines

Establish and maintain the organization's process performance baselines. *[PA164.IG101.SP104]*

SP 1.5 Establish Process Performance Models

Establish and maintain the process performance models for the organization's set of standard processes. *[PA164.IG101.SP105]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the organizational process performance process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined organizational process performance process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the organizational process performance process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the organizational process performance process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the organizational process performance process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the organizational process performance process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the organizational process performance process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the organizational process performance process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the organizational process performance process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the organizational process performance process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational process performance process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the organizational process performance process with higher level management and resolve issues. *[GP112]*

QUANTITATIVE PROJECT MANAGEMENT

Maturity Level 4

The purpose of the Quantitative Project Management process area is to quantitatively manage the project's defined process to achieve the project's established quality and process-performance objectives. [PA165]

Specific and Generic Goals

SG 1 **Quantitatively Manage the Project**

The project is quantitatively managed using quality and process-performance objectives. *[PA165.IG101]*

SG 2 **Statistically Manage Subprocess Performance**

The performance of selected subprocesses within the project's defined process is statistically managed. *[PA165.IG102]*

GG 3 **Institutionalize a Defined Process**

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 **Quantitatively Manage the Project**

The project is quantitatively managed using quality and process-performance objectives. *[PA165.IG101]*

SP 1.1 **Establish the Project's Objectives**

Establish and maintain the project's quality and process-performance objectives. *[PA165.IG101.SP101]*

SP 1.2 **Compose the Defined Process**

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

[PA165.IG101.SP102]

SP 1.3 Select the Subprocesses that Will Be Statistically Managed

Select the subprocesses of the project's defined process that will be statistically managed. *[PA165.IG101.SP103]*

SP 1.4 Manage Project Performance

Monitor the project to determine whether the project's objectives for quality and process performance will be satisfied, and identify corrective action as appropriate. *[PA165.IG101.SP104]*

SG 2 Statistically Manage Subprocess Performance

The performance of selected subprocesses within the project's defined process is statistically managed. *[PA165.IG102]*

SP 2.1 Select Measures and Analytic Techniques

Select the measures and analytic techniques to be used in statistically managing the selected subprocesses. *[PA165.IG102.SP101]*

SP 2.2 Apply Statistical Methods to Understand Variation

Establish and maintain an understanding of the variation of the selected subprocesses using the selected measures and analytic techniques. *[PA165.IG102.SP102]*

SP 2.3 Monitor Performance of the Selected Subprocesses

Monitor the performance of the selected subprocesses to determine their capability to satisfy their quality and process-performance objectives, and identify corrective action as necessary. *[PA165.IG102.SP103]*

SP 2.4 Record Statistical Management Data

Record statistical and quality management data in the organization's measurement repository. *[PA165.IG102.SP104]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the quantitative project management process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined quantitative project management process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the quantitative project management process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the quantitative project management process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the quantitative project management process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the quantitative project management process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the quantitative project management process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the quantitative project management process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the quantitative project management process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the quantitative project management process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the quantitative project management process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the quantitative project management process with higher level management and resolve issues. *[GP112]*

MATURITY LEVEL: 5

ORGANIZATIONAL INNOVATION AND DEPLOYMENT

Maturity Level 5

The purpose of Organizational Innovation and Deployment is to select and deploy incremental and innovative improvements that measurably improve the organization's processes and technologies. The improvements support the organization's quality and process-performance objectives as derived from the organization's business objectives. [PA161]

Specific and Generic Goals

SG 1 **Select Improvements**

Process and technology improvements that contribute to meeting quality and process-performance objectives are selected. *[PA161.IG101]*

SG 2 **Deploy Improvements**

Measurable improvements to the organization's processes and technologies are continually and systematically deployed. *[PA161.IG102]*

GG 3 **Institutionalize a Defined Process**

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 **Select Improvements**

Process and technology improvements that contribute to meeting quality and process-performance objectives are selected. *[PA161.IG101]*

SP 1.1 **Collect and Analyze Improvement Proposals**

Collect and analyze process- and technology-improvement proposals. *[PA161.IG101.SP101]*

SP 1.2 **Identify and Analyze Innovations**

Identify and analyze innovative improvements that could increase the organization's quality and process performance. *[PA161.IG101.SP102]*

SP 1.3 Pilot Improvements

Pilot process and technology improvements to select which ones to implement. *[PA161.IG101.SP103]*

SP 1.4 Select Improvements for Deployment

Select process- and technology-improvement proposals for deployment across the organization. *[PA161.IG101.SP104]*

SG 2 Deploy Improvements

Measurable improvements to the organization's processes and technologies are continually and systematically deployed. *[PA161.IG102]*

SP 2.1 Plan the Deployment

Establish and maintain the plans for deploying the selected process and technology improvements. *[PA161.IG102.SP101]*

SP 2.2 Manage the Deployment

Manage the deployment of the selected process and technology improvements. *[PA161.IG102.SP102]*

SP 2.3 Measure Improvement Effects

Measure the effects of the deployed process and technology improvements. *[PA161.IG102.SP103]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the organizational innovation and deployment process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined organizational innovation and deployment process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the organizational innovation and deployment process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the organizational innovation and deployment process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the organizational innovation and deployment process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the organizational innovation and deployment process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the organizational innovation and deployment process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the organizational innovation and deployment process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the organizational innovation and deployment process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the organizational innovation and deployment process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational innovation and deployment process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the organizational innovation and deployment process with higher level management and resolve issues. *[GP112]*

CAUSAL ANALYSIS AND RESOLUTION

Maturity Level 5

The purpose of Causal Analysis and Resolution is to identify causes of defects and other problems and take action to prevent them from occurring in the future. [PA155]

Specific and Generic Goals

SG 1 **Determine Causes of Defects**

Root causes of defects and other problems are systematically determined. *[PA155.IG101]*

SG 2 **Address Causes of Defects**

Root causes of defects and other problems are systematically addressed to prevent their future occurrence. *[PA155.IG102]*

GG 3 **Institutionalize a Defined Process**

The process is institutionalized as a defined process. *[CL104.GL101]*

Practices by Goal:

SG 1 **Determine Causes of Defects**

Root causes of defects and other problems are systematically determined. *[PA155.IG101]*

SP 1.1 **Select Defect Data for Analysis**

Select the defects and other problems for analysis. *[PA155.IG101.SP101]*

SP 1.2 **Analyze Causes**

Perform causal analysis of selected defects and other problems and propose actions to address them. *[PA155.IG101.SP102]*

SG 2 **Address Causes of Defects**

Root causes of defects and other problems are systematically addressed to prevent their future occurrence. *[PA155.IG102]*

SP 2.1 Implement the Action Proposals

Implement the selected action proposals that were developed in causal analysis. *[PA155.IG102.SP101]*

SP 2.2 Evaluate the Effect of Changes

Evaluate the effect of changes on process performance. *[PA155.IG102.SP102]*

SP 2.3 Record Data

Record causal analysis and resolution data for use across the project and organization. *[PA155.IG102.SP103]*

GG 3 Institutionalize a Defined Process

The process is institutionalized as a defined process. *[CL104.GL101]*

Commitment to Perform

GP 2.1 (CO 1) Establish an Organizational Policy

Establish and maintain an organizational policy for planning and performing the causal analysis and resolution process. *[GP103]*

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined causal analysis and resolution process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the plan for performing the causal analysis and resolution process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the causal analysis and resolution process, developing the work products, and providing the services of the process. *[GP105]*

GP 2.4 (AB 4) Assign Responsibility

Assign responsibility and authority for performing the process, developing the work products, and providing the services of the causal analysis and resolution process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the causal analysis and resolution process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the causal analysis and resolution process under appropriate levels of configuration management. *[GP109]*

GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders

Identify and involve the relevant stakeholders of the causal analysis and resolution process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the causal analysis and resolution process against the plan for performing the process and take appropriate corrective action. *[GP110]*

GP 3.2 (DI 4) Collect Improvement Information

Collect work products, measures, measurement results, and improvement information derived from planning and performing the causal analysis and resolution process to support the future use and improvement of the organization's processes and process assets. *[GP117]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the causal analysis and resolution process against its process description, standards, and procedures, and address noncompliance. *[GP113]*

GP 2.10 (VE 2) Review Status with Higher Level Management

Review the activities, status, and results of the causal analysis and resolution process with higher level management and resolve issues. *[GP112]*

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13. ABSTRACT (MAXIMUM 200 WORDS)

Capability Maturity Model Integration (CMMI[SM]) models have evolved the Capability Maturity Model (CMM®) concept, established by the Capability Maturity Model for Software (SW-CMM), to a new level that enables the continued growth and expansion of the CMM concept to multiple disciplines. Like the SW-CMM, EIA/IS 731, IPD-CMM, and other process improvement models, CMMI models are tools that help organizations improve their processes. This CMMI model is designed to help organizations improve their product and service development, acquisition, and maintenance processes. Concepts covered by this model include systems engineering, software engineering, and integrated product and process development as well as traditional CMM concepts such as process management and project management. Each CMMI model is designed to be used in concert with other CMMI models, making it easier for organizations to pursue enterprise-wide process improvement at their own pace. This CMMI model has a staged representation, which focuses on measuring process improvement using maturity levels. Maturity levels apply to process-improvement achievement across the organizational unit using the model.

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