Carnegie Mellon
Software Engineering Institute
Pittsburgh, PA 15213-3890

CMMI[SM] for Systems Engineering/Software Engineering/Integrated Product and Process Development, Version 1.02

CMMI[SM]-SE/SW/IPPD, V1.02

Staged Representation

CMU/SEI-2000-TR-030
ESC-TR-2000-095

CMMI Product Development Team

November 2000

Unlimited distribution subject to the copyright.

This report was prepared for the

SEI Joint Program Office
HQ ESC/DIB
5 Eglin Street
Hanscom AFB, MA 01731-2116

The ideas and findings in this report should not be construed as an official DoD position. It is published in the interest of scientific and technical information exchange.

FOR THE COMMANDER

Joanne E. Spriggs
Contracting Office Representative

This work is sponsored by the U.S. Department of Defense. The Software Engineering Institute is a federally funded research and development center sponsored by the U.S. Department of Defense.

Copyright 2000 by Carnegie Mellon University.

NO WARRANTY

THIS CARNEGIE MELLON UNIVERSITY AND SOFTWARE ENGINEERING INSTITUTE MATERIAL IS FURNISHED ON AN "AS-IS" BASIS. CARNEGIE MELLON UNIVERSITY MAKES NO WARRANTIES OF ANY KIND, EITHER EXPRESSED OR IMPLIED, AS TO ANY MATTER INCLUDING, BUT NOT LIMITED TO, WARRANTY OF FITNESS FOR PURPOSE OR MERCHANTABILITY, EXCLUSIVITY, OR RESULTS OBTAINED FROM USE OF THE MATERIAL. CARNEGIE MELLON UNIVERSITY DOES NOT MAKE ANY WARRANTY OF ANY KIND WITH RESPECT TO FREEDOM FROM PATENT, TRADEMARK, OR COPYRIGHT INFRINGEMENT.

Use of any trademarks in this report is not intended in any way to infringe on the rights of the trademark holder.

Internal use. Permission to reproduce this document and to prepare derivative works from this document for internal use is granted, provided the copyright and "No Warranty" statements are included with all reproductions and derivative works.

External use. Requests for permission to reproduce this document or prepare derivative works of this document for external and commercial use should be addressed to the SEI Licensing Agent.

This work was created in the performance of Federal Government Contract Number F19628-00-C-0003 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center. The Government of the United States has a royalty-free government-purpose license to use, duplicate, or disclose the work, in whole or in part and in any manner, and to have or permit others to do so, for government purposes pursuant to the copyright license under the clause at 52.227-7013.

For information about purchasing paper copies of SEI reports, please visit the publications portion of our Web site (http://www.sei.cmu.edu/publications/pubweb.html).

The following service marks and registered trademarks are used in this document:
Capability Maturity Model
CMM
CMM Integration℠
CMMI℠

Capability Maturity Model and CMM are registered trademarks in the U.S. Patent and Trademark Office.
CMM Integration and CMMI are service marks of Carnegie Mellon University.

Preface

The Capability Maturity Model® [1] Integration (CMMI[SM2]) project has involved a large number of people from different organizations throughout the world. These organizations were using one or more CMMs® and were interested in the benefits of developing an integration framework to aid in enterprise-wide process improvement and integration activities. [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, the CMMI model, and supporting products. These organizations donated the time of one or more of their people to participate in the CMMI project. [FM101.T103]

Model Development History

As CMMI project team, we have been working to provide systems engineering and software engineering 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 practices, and integrated product and process development. [FM101.HDA101.T102]

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

Although these models have proven useful to many organizations, the use of multiple models has been problematic. Many organizations would like to focus their improvement efforts across the disciplines within their organizations. However, the differences among these discipline-specific models, including their architecture, content, and approach, has limited these organizations' ability to focus their improvement successfully. Further, applying multiple models that are not integrated within and across an organization becomes more costly in terms of training, assessments, and improvement activities. A model that successfully integrates disciplines and has integrated training and assessment support would address these problems. [FM101.HDA101.T103]

The CMM Integration[SM3] project was formed to sort out the problem of using multiple CMMs. Our project'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 model for use by organizations pursuing enterprise-wide process improvement. [FM101.HDA101.T106]

Developing this model has involved more than simply adding existing model materials together. Using processes that promote consensus, we have 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, we created a cohesive integrated model that can be adopted by those currently using other CMMs as well as by those new to the CMMI concept. [FM101.HDA101.T108]

Our mission included the development of a common framework for supporting the future integration of other discipline-specific CMMI models. Furthermore, our mission contained the objective of ensuring 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]

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

Acknowledgments

Many talented people were involved as part of our development team for the CMMI Product Suite[4]. Three primary groups involved in this development have been the steering group, product development team, and stakeholder/reviewers. [FM101.HDA102.T101]

The steering group guides and approves the plans of the product development team, provides consultation on significant CMMI project issues, and ensures involvement from a variety of interested communities. [FM101.HDA102.T102]

The product development team writes, reviews, revises, discusses, and agrees on the structure and technical content of the CMMI Product Suite1 including the framework, model, training, and assessment materials. Development activities were based on an A-Specification provided by the steering group, the three source models, and comments from stakeholder and steering group members. [FM101.HDA102.T104]

The stakeholder/reviewer group of organizations provided valuable insight in the early effort that was used to combine the models. Their review of both the pre-release version (v0.1) and the piloted version 0.2 gave the product development team valuable organizational perspectives. [FM101.HDA102.T105]

Version 0.2 was publicly reviewed and used in initial pilot activities. Following release of that version, improvement has been guided by change requests from the public review, piloting organizations, and various focus group sessions. The product development team, led by the CMMI Editor team, evaluated over 3,000 change requests to create this version. But as with any release, the opportunity for further improvement remains. We have begun planning for version 1.1 to accommodate further improvements from early use of this model. [FM101.HDA102.T106]

The CMMI product development team has had the benefit of two distinguished leaders during the last 2-1/2 years. Project manager, Jack Ferguson, led the CMMI development team from the project's inception through to the release of CMMI-SE/SW V0.2. Project manager, Mike Phillips, led the team from the release of CMMI-SE/SW V0.2 to the present. [FM101.HDA102.T107]

[4] The CMMI Product Suite is the set of products produced from the CMMI Framework, which includes the framework itself, models, assessment materials, and training materials.

Members of the CMMI Editor team played a critical role in releasing this model. In fact, this team was primarily responsible for guiding revision of the model from V0.2 to V1.0. The Editor team served as the core model development team, configuration control board, and decision-making body for the model revision. Members contributed many hours of intensive work that resulted in Version 1.0. [FM101.HDA102.T108]

In particular, we wish to recognize the following Editor team members: [FM101.HDA102.T109]

- Dennis Ahern (Editor team co-leader)
- Jim Armstrong
- Roger Bate (chief architect)
- Aaron Clouse
- Mary Beth Chrissis
- Rick Hefner
- Craig Hollenbach
- Dave Kitson
- Mike Konrad (Editor team co-leader)
- John Kordik
- Chris Kormos
- Mike Phillips
- Karen Richter
- Sandy Shrum

The database architect and configuration manager, Mark Cavanaugh, also played a key role in producing the model and preparing the team for future model releases. Carolyn Tady, the team's administrative coordinator, provided accurate and efficient support in entering information into the database. [FM101.HDA102.T110]

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

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 additional sources. Many of these sources we have documented on the CMMI Web site, which is located at http://www.sei.cmu.edu/cmmi/ [FM101.HDA103.T101]

Feedback Information

We are very interested in your ideas for improving these products. You can help these products continually improve. [FM101.HDA104.T101]

See the CMMI Web site for information on how to provide feedback: http://www.sei.cmu.edu/cmmi/ [FM101.HDA104.T102]

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

Table of Contents

Preface **iii**
Model Development History iii
Acknowledgments v
Where to Look for Additional Information vi
Feedback Information vii

1 Introduction **13**
Selecting a CMMI Model 13
Representations: Continuous or Staged? 13
Continuous Representation 13
Staged Representation 14
Disciplines and Environments: Which to Choose? 14
Systems Engineering 15
Software Engineering 15
Integrated Product and Process Development 15
About CMMI Models 16
The Content of CMMI Models 17
About the Model You Selected 18
Typographical Conventions 18
Specific and Generic Goals 19
Specific and Generic Practices 19
References 19
Introductory Notes, Typical Work Products, and Subpractices 19
Generic Practice Elaborations 20
Discipline Amplifications 20
Numbering Scheme 20
Database Codes 21

2 Structure of the Model **22**
Structural Overview 22
Maturity Levels 23
Skipping Maturity Levels 24
Required, Expected, and Informative Components 25
Model Components 26
Process Areas 26
Specific Goals 28
Specific Practices 28

247 Generic Goals 28
248 Common Features 29
249 Generic Practices 29
250 Typical Work Products 29
251 Subpractices 30
252 Discipline Amplifications 30
253 Generic Practice Elaborations 30
254 References 30
255 Model Representation Comparison 30

256 **3 Model Terminology 32**
257 Terminology Evolution 32
258 Common Terminology with Special Meaning 32
259 Adequate, appropriate, as needed 33
260 Establish and Maintain 33
261 Independent Group 33
262 Stakeholder 33
263 Manager 33
264 Project Manager 34
265 Senior Manager 34
266 Organization 34
267 Enterprise 34
268 Development 34
269 Project 35
270 Product 35
271 Work Product 35
272 Product Component 35
273 Assessment 36
274 Objective Review 36
275 Tailoring Guidelines 36
276 Project Development Plan 36
277 ISO/IEC 15504 Compatibility and Conformance 37
278 Integrated 37
279 Verification and Validation 38
280 Goal 38
281 Objective 38
282 Practice 38
283 Standard 38
284 CMMI-Specific Terminology 38
285 CMMI Product Suite 39
286 CMMI Framework 39
287 CMMI Model 39
288 Process Area 39

289 Subpractice 40
290 Typical Work Product 40
291 Peer Review 40
292 Organization's Set of Standard Processes 40
293 Defined Process 41
294 Organizational Process Assets 41
295 Process Architectures 41
296 Process Elements 42
297 Product Life Cycle 42
298 Organizational Measurement Repository 42
299 Organizational Library of Process-Related Documentation 43

300 **4 Maturity Levels, Common Features, and Generic Practices 44**
301 Overview 44
302 Maturity Levels 44
303 Maturity Level 1: Initial 45
304 Maturity Level 2: Managed 45
305 Maturity Level 3: Defined 46
306 Maturity Level 4: Quantitatively Managed 48
307 Maturity Level 5: Optimizing 49
308 Common Features 51
309 Generic Practices Listed by Common Feature 51

310 **5 Understanding the Model 61**
311 Four Categories of CMMI Process Areas 61
312 Process Management Processes 62
313 The Scope of Process Management Processes 62
314 Basic Process Management Process Areas 62
315 Advanced Process Management Process Areas 64
316 Project Management Processes 66
317 The Scope of Project Management Processes 66
318 Basic Project Management Process Areas 66
319 Advanced Project Management Process Areas 68
320 Engineering Processes 70
321 The Scope of Engineering Processes 70
322 Interactions Among Engineering Process Areas 71
323 Engineering Process Areas and Recursion 74
324 Support Processes 75
325 The Scope of Support 75
326 Basic Support Process Areas 75
327 Advanced Support Process Areas 77

328 **6 Using the Model 79**

Interpreting the Model 79
Assessing for Process Improvement and Benchmarking 80
Assessment Requirements for CMMI 82
Making the Transition to CMMI 82
Organizations with Software CMM Experience 83
Organizations with SECM Experience 84
Organizations Without Experience in Either Model 84
Training 85
Tailoring Criteria 85
Model Tailoring Perspectives 86
Model Tailoring Criteria for Internal Process Improvement 86
Model Tailoring Criteria for Benchmarking 87
Model Tailoring for Smaller Projects 88
Assessment Tailoring Criteria 89

7 Process Areas 90
Maturity Level: 2 Managed 91
Requirements Management 92
Project Planning 103
Project Monitoring and Control 132
Supplier Agreement Management 146
Measurement and Analysis 163
Process and Product Quality Assurance 182
Configuration Management 192
Maturity Level: 3 Defined 209
Requirements Development 210
Technical Solution 233
Product Integration 261
Verification 283
Validation 301
Organizational Process Focus 314
Organizational Process Definition 333
Organizational Training 350
Integrated Project Management (IPPD) 368
Risk Management 402
Integrated Teaming 422
Decision Analysis and Resolution 438
Organizational Environment for Integration 452
Maturity Level: 4 Quantitatively Managed 472
Organizational Process Performance 473
Quantitative Project Management 487
Maturity Level: 5 Optimizing 513
Organizational Innovation and Deployment 514

Causal Analysis and Resolution 534

Appendixes 548

A. References 549

Publicly Available Sources 549

Sources Not Publicly Available 552

B. Acronyms 553

C. Glossary 556

D. Required and Expected Model Elements 582

Maturity Level: 2 583

Requirements Management 584

Project Planning 587

Project Monitoring and Control 592

Supplier Agreement Management 596

Measurement and Analysis 600

Process and Product Quality Assurance 604

Configuration Management 608

Maturity Level: 3 612

Requirements Development 613

Technical Solution 618

Product Integration 623

Verification 628

Validation 632

Organizational Process Focus 636

Organizational Process Definition 640

Organizational Training 644

Integrated Project Management (IPPD) 648

Risk Management 653

Integrated Teaming 657

Decision Analysis and Resolution 661

Organizational Environment for Integration 665

Maturity Level: 4 669

Organizational Process Performance 670

Quantitative Project Management 674

Maturity Level: 5 678

Organizational Innovation and Deployment 679

Causal Analysis and Resolution 683

E. CMMI Project Participants 687

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 disciplines. 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-Integrated (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 may not map one-to-one with the processes used in your organization. [FM108.T102]

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 which disciplines 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 maturity levels through the use of equivalent staging
- Provide an easy migration from EIA/IS 731 to CMMI
- Afford an easy comparison of process improvement to ISO/IEC 15504 because the organization of process areas is derived from 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 using maturity levels
- Provide an easy migration from the SW-CMM to CMMI
- Allow comparison to ISO/IEC 15504, but the organization of process areas does not correspond to the organization used in ISO/ IEC 15504

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

Disciplines and Environments: Which to Choose?

Currently there are two disciplines and one development environment included in the CMMI model: systems engineering and software engineering disciplines and the integrated product and process development environment. Distinctions between the systems engineering and software engineering material is limited to amplifications that are more appropriate to one discipline than the other. Consequently, we recommend that you select both systems and software engineering when selecting a CMMI model, even if you are interested in only one of these disciplines, because the only distinction between the two is at the level of amplifications to practices within otherwise identical process areas. [FM108.HDA101.HDB104.T102]

The differences between the IPPD material and the systems engineering/software engineering material can be summarized as follows: [FM108.HDA101.HDB104.T103]

- Two additional process areas
- A number of amplifications throughout the process areas
- A revised Integrated Project Management (IPPD) process area
- A new definition in the glossary
- Two new entries in the acronym list
- A revised equivalent staging graphic (in the continuous representation)
- Some new and revised material in the Overview section of the model

Systems Engineering

The systems engineering discipline 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 those product solutions throughout the product life cycle. [FM108.HDA101.HDB105.T101]

Software Engineering

The software engineering discipline 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]

Integrated Product and Process Development

Integrated Product and Process Development (IPPD) is a systematic approach to product development that achieves a timely collaboration of relevant stakeholders throughout the product life cycle to better satisfy customer needs. The CMMI-SE/SW/IPPD model captures the underlying best practices exhibited by a good IPPD approach. These practices may be used in developing, improving, or appraising the implementation of IPPD. [FM108.HDA101.HDB107.T101]

IPPD is not a separate discipline, but an approach and an environment in which a project or organization performs the CMMI-SE/SW/IPPD processes. The IPPD processes are integrated with the processes in the CMMI-SE/SW model. The IPPD process areas, specific goals, and specific practices alone cannot achieve IPPD. If a project or organization chooses IPPD, it performs the IPPD practices concurrently with the systems engineering and/or software engineering practices. That is, if an organization or project wishes to use the IPPD environment, it chooses the CMMI-SE/SW/IPPD model.[5] [FM108.HDA101.HDB107.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 practices into a structure that helps your organization assess its organizational maturity or process area capability, establish priorities for improvement, and implement these improvements. [FM108.HDA102.T101]

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. CMM Integration can serve as a guide for organizational self-improvement. [FM108.HDA102.T102]

The CMMI Product Suite contains and is produced from a framework that provides the ability to generate multiple models and associated training and assessment materials. These models may represent software and systems engineering, integrated product and process development, newly identified disciplines, or combinations of disciplines. [FM108.HDA102.T103]

Professional judgment should be used by your organization to interpret CMMI practices. Although process areas depict behavior that should be exhibited in any organization, practices must be interpreted using an in-depth knowledge of the CMMI model, the organization, the business environment, and the specific circumstances involved. [FM108.HDA102.T104]

[5] Additional information on IPPD background, benefits, and implementation guidance can be found in published Technical Notes at http://www.sei.cmu.edu/cmmi/.

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 the model, suggestions on where to look for other information not included in this volume, and the typographical conventions used throughout the model.
- Chapter 2: The Structure of the Model chapter describes the components of the model, including maturity levels, goals, and practices.
- Chapter 3: The Model Terminology chapter describes the approach taken to using terms in the model as well as how terms were selected and defined in the glossary.
- Chapter 4: The Maturity Levels, Common Features, and Generic Practices chapter describes the maturity levels, generic goals, and generic practices, which ensure that the implementation of process areas is effective, repeatable, and lasting.
- Chapter 5: The Understanding the Model chapter provides insight into the meaning of the model for your organization.
- Chapter 6: The Using the Model chapter explains the ways in which your organization can use the model.
- Chapter 7: The Process Areas chapter contains descriptions of the required, expected, and informative components of the model, including goals, practices, subpractices, and typical work products.

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

- Appendix A: The References appendix contain 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 Product Suite.
- Appendix B: The Acronym List appendix defines acronyms used in the CMMI models.
- Appendix C: The Glossary appendix defines terms used in the CMMI Product Suite that are not adequately defined in the context of this model by the Webster's American English dictionary.
- Appendix D: The Required and Expected Model Components appendix contains the required and expected components for each of the process areas. No informative material is given other than the process area purpose, titles, and component names. This view of the model is convenient when you want to quickly understand the content and flow of large portions of the model or are intimately familiar with it.

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

About the Model You Selected

All CMMI models contain common elements that you can use to improve processes. This model is designed specifically for organizations interested in improving processes in both systems engineering and software engineering disciplines in an integrated product and process development environment. [FM108.HDA104.T101]

The CMMI model for systems engineering/software engineering/integrated product and process development (CMMI-SE/SW/IPPD) consists of the same process areas, regardless of representation (continuous or staged). Each process area contains goals, practices, typical work products, and other informative components. (See Structure of the Model for more information about the model components within each process area.) [FM108.HDA104.T104]

In the Understanding the Model chapter you will find descriptions of all process area categories and the process areas that belong to them. This chapter provides a high-level view of the model that is designed to help you understand the interactions that occur between and among process areas. [FM108.HDA104.T105]

Since you have chosen IPPD, you will find that descriptions of the IPPD components, how they interact with other process areas, and how they fit into the process area categories will also be included in the discussion. [FM108.HDA104.T106]

Typographical Conventions

We designed the CMMI model format with typographical conventions that optimize its 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]

Refer to the Structure of the Model chapter to see definitions of the model components mentioned. [FM108.HDA105.T101.R101]

Specific and Generic Goals

All goal names and statements within the process areas appear in bold with the goal number (for example, SG 1 for specific goal 1 or GG 1 for generic goal 1) appearing on the left side of the page. The goal name is not used for assessments or rated in any way. Only the goal statement is designed to be used for process improvement and assessment purposes. Here is an example: [FM108.HDA105.HDB101.T101]

SG 1. Establish Estimates

Estimates of project planning parameters are established and maintained. ***[FM108.HDA105.HDB101.T102]***

Specific and Generic Practices

All specific practice names within the process areas appear in bold and the practice statements appear in bold italics within a gray box indicating that it is the statement that you use for process improvement and assessments, not the name. The name is only used for easy reference. Here is an example: [FM108.HDA105.HDB102.T101]

SP 2.1 Select Suppliers

Select suppliers based on an evaluation of their ability to meet the specified requirements. ***[FM108.HDA105.HDB102.T102]***

References

All references to components are identifiable in the model, because they always appear in italics. Here is an example: [FM108.HDA105.HDB103.T101]

Refer to the Decision Analysis and Resolution process area for more information about formal decision making. *[FM108.HDA105.HDB103.T101.R101]*

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]

Generic Practice Elaborations

Within the common features[6] of every process area, the generic practice names and statements (in bold and bold italics respectively) appear for the generic practices 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, it is because we judged the application of the generic practice to be obvious without it. [FM108.HDA105.HDB105.T101]

Discipline Amplifications

Model components that provide guidance for interpreting model information for specific disciplines (for example, systems engineering or software engineering) are called "discipline amplifications." These are easy to locate because they appear near 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, we numbered specific goals so that they correspond to the specific goals in the staged. Each specific goal has a number beginning with SG, for example, SG1. [FM108.HDA105.HDB107.T101]

Specific practices are numbered so that you can identify to which goal the practice is mapped and its sequence number. For example, in the Requirements Management process area, the first practice is numbered SP1.1 and the second is SP1.2. (In the continuous representation, each practice number also indicates the capability level [for example, SP1.1-1 indicates a practice at capability level one].) [FM108.HDA105.HDB107.T103]

The generic goals are numbered the same as the specific goals; however, since this numbering scheme ensures that goals and practices in the two representations have the same numbers, the generic goals will either begin with GG2 or GG3 in the staged representation. [FM108.HDA105.HDB107.T108]

The generic practices have both the numbering described above for specific practices and a second number that indicates the common feature group to which it belongs and the sequence number within the common feature. For example, the first generic practice associated with GG2 is numbered GP2.1 and CO 1. The GP 2.1 number corresponds to the generic practice number used in the continuous representation. The CO 1 number indicates that the generic practice is the first practice organized under the Commitment to Perform common feature. [FM108.HDA105.HDB107.T109]

[6] Common features are model components that group generic goals and practices into categories.

Refer to the Structure of the Model chapter for more information about common features. *[FM108.HDA105.HDB107.T110]*

The numbering scheme used in each representation enables you to easily find the practice in the continuous representation that corresponds to the practice in the staged representation.

[FM108.HDA105.HDB107.T111]

Database Codes

At the end of lines and paragraphs throughout the Process Area section of the model, you will find a short sequence of numbers and letters in very small type set off in brackets that look like this: [PA150.EL112]. These are codes for the database, and you can just ignore them.

[FM108.HDA105.HDB108.T101]

2 Structure of the Model

Of the two representations of the CMMI model, you have chosen the staged representation. The components of both 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 maturity levels to support and guide process improvement. 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 in the process areas. [FM103.T104]

In this chapter, we describe each component of the model you have chosen, 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 staged representation. [FM103.T106]

Structural Overview

A CMMI model with a staged representation is illustrated in Figure 1. [FM103.HDA101.T102]

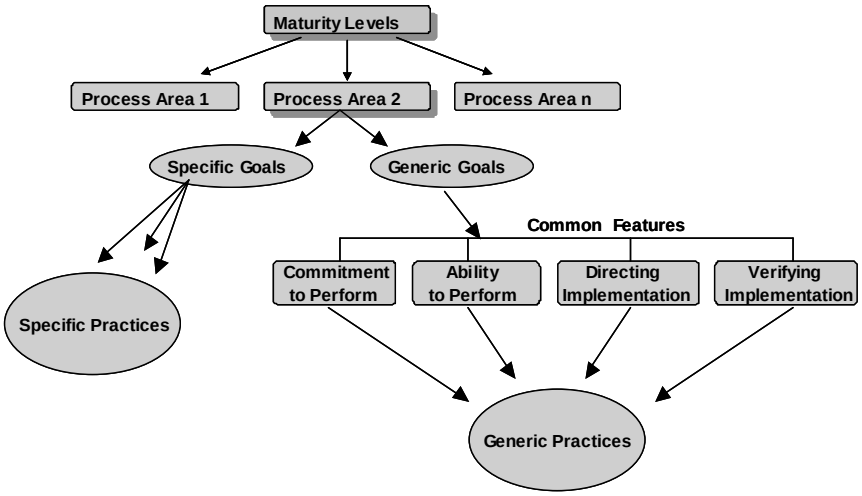

Figure 1: CMMI Model Components [FM103.HDA101.T104]

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 so that not all process areas are addressed at the same time. 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. Generic practices are organized by common features. [FM103.HDA101.T106]

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 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. Achieving each maturity level results in an increase in the process capability of the organization. [FM103.HDA101.HDB101.T102]

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]

- Initial
- Managed
- Defined
- Quantitatively Managed
- Optimizing

Maturity levels are measured by the achievement of the specific and generic goals that apply to a predefined set of process areas. The characteristics of these levels are described in the Maturity Levels, Common Features, and Generic Practices chapter. [FM103.HDA101.HDB101.T105]

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 controls. As your organization achieves the generic and specific goals for a the set of process areas in a maturity level, you are increasing your organization's process maturity and reaping the benefits of process improvement. [FM103.HDA101.HDB101.T107]

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.HDB102.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 higher-level practices 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 an engineering process group, which is an attribute of maturity level 3 organizations. While this group is not a necessary characteristic of a maturity level 2 organization, it can be a useful part of the organization's strategy for achieving maturity level 2. [FM103.HDA101.HDB102.T102]

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[7] has not been completed. Processes without the proper foundation may fail at the very point they are needed most - under stress. [FM103.HDA101.HDB102.T103]

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 the baselined requirements. Similarly, many organizations collect the detailed data characteristics of maturity level 4, only to find that the data are uninterpretable because of inconsistency in product development processes and measurement definitions. [FM103.HDA101.HDB102.T105]

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.HDB102.T106]

[7] Institutionalization is the building and reinforcement of infrastructure and corporate culture that support methods, practices, and procedures so that they are the ongoing way of doing business, even after those who originally defined them are gone.

Another example of using processes from 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, build, and verification. However, these activities are not described until maturity level 3 where they are described as coherent, well-integrated engineering processes. [FM103.HDA101.HDB102.T107]

Such variations in implementing process improvement practices are artifacts for the way process areas are defined. A process area in the staged representation describes a fully implemented and institutionalized process—one that has been mastered by the organization. A maturity level 1 organization could implement almost any process described in this model, although perhaps in an incomplete or ad hoc fashion. [FM103.HDA101.HDB102.T108]

Required, Expected, and Informative Components

All components of a CMMI model are grouped into three categories: [FM103.HDA101.HDB103.T101]

- Required: Specific goals and generic goals are required model components that are to be achieved by an organization's planned and implemented processes. Required components are considered essential to achieving process improvement in a given process area. They are used in assessments to determine process area satisfaction and organizational process maturity. 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 practices an organization that is achieving a set of specific and generic goals will typically implement. They are meant to guide individuals and groups implementing improvements or performing assessments. Either the practices as described, or acceptable alternatives to them must be present in the planned and implemented processes of the organization, before goals can be considered satisfied. Only the statement of the specific or generic practice is an expected model component. The title of a specific or generic 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 practices and goals.

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 carries out 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.[8] [FM103.HDA101.HDB103.T102]

Model Components

Process Areas

A process area is a group of related practices that are performed collectively to achieve a set of objectives, including what it does (specific practices) and the anticipated behavior (specific goals). All CMMI process areas are common to both continuous and staged representations. [FM103.HDA102.HDB101.T101]

The process areas at maturity level 2 include the following: [FM103.HDA102.HDB101.T102]

- Requirements Management manages the requirements of the project's product and product components and identifies inconsistencies between the project's plans and work products and the requirements.
- Project Planning establishes and maintains plans that define project activities.
- Project Monitoring and Control provides understanding into the project's progress so that appropriate corrective actions can be taken when the project's performance deviates significantly from the plan.
- Supplier Agreement Management manages the acquisition of products and services from suppliers external to the project for which there exists a formal agreement.
- Measurement and Analysis develops and sustains a measurement capability that is used to support management information needs.
- Process and Product Quality Assurance provides staff and management with objective insight into the processes and associated work products.
- Configuration Management establishes and maintains the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits.

[8] For additional information about alternative practices, see the Model Terminology section.

The process areas at maturity level 3 include: [FM103.HDA102.HDB101.T104]

- Requirements Development produces customer, product, and product component requirements and analyses required for their development and understanding.
- Technical Solution develops, designs, and implements solutions to requirements. Solutions, designs and implementations encompass products, product components, and product related processes either singly or in combinations as appropriate.
- Product Integration assembles the product from the product components, ensures that the product, as integrated, functions properly, and delivers the product.
- Verification assures that selected work products meet their specified requirements.
- Validation demonstrates that a product or product component fulfills its intended use when placed in its intended environment.
- Organizational Process Focus establishes and maintains an understanding of the organization's processes and process assets, and identifies, plans, and implements the organization's process improvement activities.
- Organizational Process Definition establishes and maintains a usable set of organizational process assets.
- Organizational Training develops the skills and knowledge of people so they can perform their roles effectively and efficiently.
- Integrated Project Management (IPPD) establishes and manages 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. It 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.
- Risk Management identifies potential problems before they occur, so that risk handling activities may be planned and invoked as needed across the lifecycle to mitigate adverse impacts on achieving objectives.
- Decision Analysis and Resolution makes decisions using a structured approach that evaluates identified alternatives against established criteria.
- Organizational Environment for Integration provides an IPPD infrastructure and manages people for integration.
- Integrated Teaming forms and sustains an integrated team for the development of work products.

The process areas at maturity level 4 include: [FM103.HDA102.HDB101.T105]

- Organizational Process Performance establishes and maintains a quantitative understanding of the performance of the organization's set of standard processes and provides the process performance data, baselines, and models to quantitatively manage the organization's projects.
- Quantitative Project Management quantitatively manages the project's defined process to achieve the project's established quality and process performance objectives.

The process areas at maturity level 5 include: [FM103.HDA102.HDB101.T106]

- Organizational Innovation and Deployment selects and deploys 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.
- Causal Analysis and Resolution identifies causes of defects and other problems and takes action to prevent them from occurring in the future.

Specific Goals

Specific goals apply to only one process area and address the unique characteristics that describe what must be implemented to satisfy the purpose of the process area. Goals are required model components and are used in assessments to 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 specific goal that it is mapped to. The specific practices describe the activities expected to result in achievement of the specific goal of a process area. [FM103.HDA102.HDB104.T101]

Generic Goals

Generic goals apply to all process areas. Achievement of each of these goals in each process area signifies whether the implementation and institutionalization of each process area is effective, repeatable, and lasting. Generic goals and generic practices appear in chapter 4. [FM103.HDA102.HDB105.T101]

Common Features

Four common features organize the generic practices of each process area. Common feature names are model components that are informative. They are only groupings that provide a way to present the generic practices. Each is designated in the model by an abbreviation as shown. [FM103.HDA102.HDB106.T101]

Commitment to Perform (CO) groups all generic practices related to creating policies and securing sponsorship for process improvement efforts. [FM103.HDA102.HDB106.T102]

Ability to Perform (AB) groups all generic practices related to ensuring that the project and/or organization has the resources it needs to pursue process improvement. [FM103.HDA102.HDB106.T103]

Directing Implementation (DI) groups the generic practices related to collecting, measuring, and analyzing data related to processes. The purpose of these activities is to provide insight into the performance of processes. [FM103.HDA102.HDB106.T104]

Verifying Implementation (VE) groups all generic practices related to verifying that the projects and/or organization's activities conform to requirements, processes, and procedures. [FM103.HDA102.HDB106.T105]

Refer to chapter four for a more detailed description of the common features. [FM103.HDA102.HDB106.T106]

Generic Practices

Generic practices are practices that apply to every process area because in principle, they can improve the performance and control of any process. Generic practices provide the institutionalization features that will ensure that the process area will be effective, repeatable, and lasting. Generic practices are expected components in the model. [FM103.HDA102.HDB107.T102]

Typical Work Products

Typical Work Products are an informative model component that provide example outputs from a 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 the model meant only to provide ideas that may or may not be used 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.” [FM103.HDA102.HDB115.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 is described. [FM103.HDA102.HDB116.T101]

Refer to the details of the generic practices in chapter 4.
[FM103.HDA102.HDB116.T101.R101]

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 Decision and Analysis and Resolution process area for determining the best integration strategy” or “Refer to the Project Planning process area for more information about global project planning.” All references are clearly marked in the model in italics. [FM103.HDA102.HDB117.T101]

Model Representation Comparison

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

- Capability levels 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 defined set of generic practices.

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

Level	Continuous Representation Capability Levels	Staged Representation Maturity Levels
Level 0	Incomplete	N/A
Level 1	Performed	Initial
Level 2	Managed	Managed
Level 3	Defined	Defined
Level 4	Quantitatively Managed	Quantitatively Managed
Level 5	Optimizing	Optimizing

[FM103.HDA103.T102]

Equivalent staging enables the results of assessments using the continuous representation to be translated into maturity levels.

[FM103.HDA103.T103]

Refer to Appendix F of the continuous representation for details of how equivalent staging is designed to work. *[FM103.HDA103.T103.R101]*

3 Model Terminology

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

Terminology Evolution

When developing the CMMI models, the product development 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, we had to decide which terms should be used and which were to be abandoned. This selection of terminology was accomplished throughout the model development process using consensus methods. [FM114.HDA101.T101]

Inevitably, consensus was reached when the terms selected were most neutral, broad, and flexible. When conflicts were identified between potential user groups (government and industry) or between discipline areas (software engineering and systems engineering), a compromise was reached. We 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 model, regardless of representation. Definitions for these terms were communicated to the entire development 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 the CMMI models have meanings attached to them that are more specific than their everyday use. Although these terms are not included in the glossary, we've explained their use in the model 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 the practice 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 as well as a usage component. 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, it must be documented and it must be used throughout the organization. [FM114.HDA102.HDB102.T101]

Independent Group

The "independent group" is a concept that a CMMI model uses when discussing quality assurance. A quality assurance group is independent if it is not involved in the development of the product in any other way and there is a separate reporting channel for escalating issues. [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 can include project members, suppliers, customers, and others. The term "relevant stakeholder" is used to designate a group or individual that is called out in a plan to perform certain types of activities or to receive certain kinds of information. [FM114.HDA102.HDB104.T101]

Manager

Within the scope of CMMI models, the word "manager" is a person that 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.HDB105.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 ultimately responsible to the customer. In some matrix organizations, only the business staff may report directly to the project manager, whereas the engineering groups report to the project manager indirectly. [FM114.HDA102.HDB106.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.HDB107.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.HDB107.T102]

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. [FM114.HDA102.HDB108.T101]

Enterprise

When CMMI models refer to an “enterprise,” they illustrate the larger entity not always reached by the word “organization.” Very large companies may consist of many organizations in many different locations with different customers. The word “enterprise” refers to the full composition of these large companies. [FM114.HDA102.HDB109.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 exclusively on maintenance, development, or both activities. [FM114.HDA102.HDB110.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. (The word “program” is not used in CMMI models.) [FM114.HDA102.HDB111.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.HDB112.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. [FM114.HDA102.HDB113.T101]

In various places in the model, 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.HDB113.T102]

Product Component

The term “product component” is used as a relative term in CMMI models. In CMMI, product components are generally lower level components of the product; product components are integrated to “build” the product. There may be multiple levels of product components. Product component is defined as any work product that must be engineered (requirements defined, designed, and integrated solution developed) to achieve the intended use of the product throughout its life cycle. [FM114.HDA102.HDB114.T101]

Product components may be a part of the product delivered to the customer or 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; 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 also examples of product components. These latter examples are product components even if they are not delivered to the customer, but developed by the project for internal use or for use by another party. [FM114.HDA102.HDB114.T102]

Assessment

CMMI follows ISO/IEC 15504 in using the term “assessment” rather than the EIA/IS 731 term, “appraisal” or using both terms, as in SW-CMM. [FM114.HDA102.HDB115.T101]

Objective Review

An “objective review” is another concept that CMMI models use when discussing quality assurance. These reviews can be done by independent groups, or by project members themselves. [FM114.HDA102.HDB116.T101]

Tailoring Guidelines

Tailoring a process makes, alters, or adapts the 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. [FM114.HDA102.HDB117.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.HDB117.T102]

Tailoring guidelines aid those who establish the defined processes for projects. Tailoring guidelines cover (1) selecting a standard process, (2) selecting an approved product life cycle, and (3) tailoring the selected standard process and life cycle to fit project needs. Tailoring guidelines describe what can and cannot be modified and identify process components that are candidates for modification. [FM114.HDA102.HDB117.T103]

Project Development Plan

The project’s defined process is usually not specific enough to be performed directly because it doesn’t specify who will assume the roles, what work products to create, or when tasks will be performed. [FM114.HDA102.HDB118.T101]

In CMMI models, the “project development plan,” as a single plan or collection of plans, links the project’s defined process to how the project will be performed. The project’s defined process and its development plan together make it possible to perform and manage the process. You can also look at a “project development plan” as a “project management plan” because it can cover product maintenance and/or product development. [FM114.HDA102.HDB118.T102]

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 assessment 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. [FM114.HDA102.HDB119.T101]

For an assessment 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 assessment process (assessment method). [FM114.HDA102.HDB119.T102]

There are also ISO/IEC 15504 requirements that pertain to the actual conduct (planning as well as performance) of an assessment. If the conduct of an assessment is such that the requirements in ISO/IEC 15504-3 are satisfied, then the assessment is said to be ISO/IEC 15504 conformant. One of these requirements is that a ISO/IEC 15504 compatible assessment model is used. [FM114.HDA102.HDB119.T103]

Integrated

When the term “integrated” is used in the CMMI Product Suite, the integration refers to the use of the models to apply to multiple disciplines. In other words, your organization’s engineering process group can learn one model that it can use to introduce process improvement into software engineering, systems engineering, and, as time goes on, more disciplines. Integration does not refer to your organization’s structure. The decision to integrate departments or development processes is best determined by analyzing business objectives. [FM114.HDA102.HDB120.T101]

Verification and Validation

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. Validation confirms that the product, as provided, will fulfill its intended use. [FM114.HDA102.HDB121.T101]

Goal

A “goal” is a required CMMI component that can be either a generic goal or specific goal. Each goal within a process area must be achieved to consider the process area to be achieved. When you see the word “goal” in a CMMI model, it always refers to model components (for example, generic goal, specific goal). [FM114.HDA102.HDB122.T101]

Objective

Instead of using “goal” in its common everyday sense, the term “objective” is used to avoid confusion. [FM114.HDA102.HDB123.T101]

Practice

A “practice” is an expected CMMI component that can be either a generic practice or specific practice. Each practice within a process area, or an equivalent alternative must be achieved to consider the process area to be achieved. Every practice supports only one goal. [FM114.HDA102.HDB124.T101]

When you see the word “practice” in a CMMI model, it always refers to model components (for example, generic practice, specific practice). Instead of using “practice” in its common everyday sense, we chose another term that means the same thing (for example, carry out, perform, apply, follow, rehearse, attempt, exercise). [FM114.HDA102.HDB124.T102]

Standard

When you see the word “standard” 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). 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.HDB125.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, assessment methods, assessment materials, and all levels and types of training that are produced from the CMMI Framework. [FM114.HDA103.HDB101.T101]

CMMI Framework

The CMMI Framework is actually a database that enables products to be generated according to selections that a user makes. The CMMI Framework is the basic structure that organizes CMMI products and components, which include common elements of the current CMMI models as well as rules and methods for generating models, their assessment 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 models. Consequently, the phrase “CMMI model” could be any one of many collections of information. It could be CMMI-SE/SW, CMMI-SE/SW/IPPD, or another model in the future when additional disciplines are added. The phrase “CMMI models” refers to one or more of these models and will most likely refer to the entire collection of possible models that can be generated from the CMMI Framework. [FM114.HDA103.HDB103.T101]

A CMMI model describes the key elements of an effective process for one or more disciplines that is generated from the CMMI Framework and conforms to the framework’s rules. [FM114.HDA103.HDB103.T102]

Process Area

A “process area” is a set of goals with a cluster of related practices that, when performed collectively, may be expected to improve an organization’s process performance. The phrase “process area” represents the large building blocks of all CMMI models. This phrase was derived from a compromise between those used by the source models. [FM114.HDA103.HDB104.T101]

Subpractice

"Subpractices" are model components that support specific and generic practices with informative material. Reading the subpractices helps you more clearly understand the scope and intent of the practices to which they belong. [FM114.HDA103.HDB105.T101]

Subpractices are listed beneath the specific and generic practices in CMMI models. They describe activities that may be implemented in establishing the specific or generic practice. Subpractices are for informational purposes only and are intended to provide clarification of the practices or ideas for possible use by the user. [FM114.HDA103.HDB105.T102]

Typical Work Product

"Typical work products" are model components that provide example outputs of a practice. These examples are called "typical work products" because there are often other work products that are just as effective, but are not listed. They help those who need examples to understand the outputs that might be expected from a practice. [FM114.HDA103.HDB106.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 the development of the work products to identify defects for removal. [FM114.HDA103.HDB107.T101]

Organization's Set of Standard Processes

An "organization's set of standard processes" contains the definitions of the basic processes that guide all processes in an organization. These process descriptions cover the fundamental process elements (and their relationships to each other) that must be incorporated into the defined processes that are implemented in projects across the organization. A standard process establishes consistent development and maintenance activities across the organization and is essential for long-term stability and improvement. [FM114.HDA103.HDB108.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.HDB108.T102]

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 organization's process assets. [FM114.HDA103.HDB109.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 development of the product and another for testing the product). [FM114.HDA103.HDB109.T102]

Organizational Process Assets

"Organizational process assets" are artifacts considered useful for defining and implementing processes in an organization. The organization maintains a collection of process assets for use by projects and others developing, tailoring, maintaining, and implementing processes. [FM114.HDA103.HDB110.T101]

The primary organizational process assets that are described in this CMMI model include the following: [FM114.HDA103.HDB110.T102]

- Organization's set of standard processes, including the process architectures and process elements
- Descriptions of project life cycles (that is, development life cycle) approved for use (for example, waterfall, spiral)
- Guidelines and criteria for tailoring the organization's set of standard processes
- Organizational measurement repository process database
- Organizational library of process-related documentation

An organization may bundle these process assets in many ways, depending on its approach to establishing its set of standard processes. For example, the description of the product life cycle may be an integral part of the organization's set of standard processes. [FM114.HDA103.HDB110.T103]

Process Architectures

A "process architecture" describes the ordering, interfaces, interdependencies, and other relationships among the process elements in a standard process. A process architecture also describes the interfaces, interdependencies, and other relationships between it and external processes (for example, contract management). [FM114.HDA103.HDB111.T101]

Process Elements

A “process element” is a fundamental unit of process description. A process may be defined in terms of subprocesses or process elements. A subprocess can be further decomposed; a process element cannot be decomposed into finer-grained descriptions. [FM114.HDA103.HDB112.T101]

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. [FM114.HDA103.HDB112.T102]

Product Life Cycle

A “product life cycle” is the period of time that begins when a product is conceived and ends when the product is no longer available for use. Since an organization may be producing multiple products for multiple customers, one product life cycle may not be adequate. Therefore, the organization may define a set of approved product life cycles. These life cycles are typically found in published literature and are likely to be modified to fit the organization. [FM114.HDA103.HDB113.T101]

An example of a product life cycle is (1) concept/vision, (2) feasibility, (3) design/development, (4) production, and (5) phase-out. A project life cycle is a different concept that describes the development process used by the project (for example, waterfall, spiral). [FM114.HDA103.HDB113.T102]

Organizational Measurement Repository

The “organizational 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 assess the measurement data. [FM114.HDA103.HDB114.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 cost amounts; peer review efficiency and coverage statistics; and the number and severity of defects. [FM114.HDA103.HDB114.T102]

Organizational Library of Process-Related Documentation

The “organizational library of process-related documentation” is a library of information used to store and make available process documents that are potentially useful to those who are defining, implementing, and managing processes in the organization. This library contains documents, document fragments, process implementation aids, and other artifacts that are useful in defining, implementing, and managing processes that are tailored from the organization’s set of standard processes. [FM114.HDA103.HDB115.T101]

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

[FM114.HDA103.HDB115.T102]

4 Maturity Levels, Common Features, and Generic Practices

Overview

The maturity levels and generic model components of CMMI models focus on the maturity of the organization's ability to pursue process improvement. Using common features, generic goals, and generic practices, users are able to improve their processes, demonstrate and evaluate their organization's progress as they improve their processes, and move from one maturity level to another. [FM122.HDA101.T101]

Maturity Levels

In the staged representation, maturity levels provide a recommended order for approaching process improvement in stages so that not all process areas are addressed at the same time. This recommended order allows organizations to focus improvement efforts on the critical few processes that will have the most benefit to the organization. Each level also provides a necessary foundation for effective implementation of the processes at the next level. [FM122.HDA102.T101]

"Institutionalization" is an important dimension to each of the maturity levels. When mentioned below in the maturity level descriptions, institutionalization implies that the implementation of the process area is appropriate to ensure that the process area is an ingrained and lasting part of the way the work is performed in the organization. [FM122.HDA102.T102]

There are five maturity levels, numbered 1 through 5. Maturity levels are measured by the achievement of the specific and generic goals that apply to the process areas at each level. [FM122.HDA102.T103]

Maturity Level 1: Initial

A maturity level 1 is typically ad hoc and chaotic. The organization typically does not provide a stable environment. Success in these organizations depends on the competence and heroics of the people in the organization and cannot be repeated unless the same competent and experienced individuals are assigned to the next project. In spite of this ad hoc, chaotic environment, maturity level 1 organizations frequently produce products that work; however, they often greatly exceed the budget and schedule of the project. [FM122.HDA102.HDB101.T101]

Maturity Level 2: Managed

At maturity level 2, an organization has achieved all of the goals of the maturity level 2 process areas. In other words, the organization has ensured that its processes are planned, documented, performed, monitored, and controlled at the project level. [FM122.HDA102.HDB102.T101]

Maturity level 2 process areas are Requirements Management, Project Planning, Project Monitoring and Control, Supplier Agreement Management, Measurement and Analysis, Process and Product Quality Assurance, and Configuration Management. [FM122.HDA102.HDB102.T102]

At maturity level 2, objectives of processes are achieved, and they are planned, documented, performed, monitored, and controlled. Furthermore, at maturity level 2, objectives established for the process, such as cost, schedule, and quality objectives are achieved. [FM122.HDA102.HDB102.T103]

The process discipline reflected by maturity level 2 helps to ensure that existing practices are retained during times of stress. When these practices are used on efforts similar to the current effort, similar results are expected. [FM122.HDA102.HDB102.T104]

At maturity level 2, the requirements, standards, and objectives for the process, its work products, and its services are defined and documented. The status of the work products and delivery of the services are visible to management at defined points (for example, at major milestones and completion of major tasks). [FM122.HDA102.HDB102.T105]

Commitments are established among relevant stakeholders. Commitments are revised as needed and satisfied. Work products are reviewed with stakeholders and are controlled. The work products and services satisfy their specified requirements, standards, and objectives. [FM122.HDA102.HDB102.T106]

At maturity level 2, institutionalization is achieved by doing the following: [FM122.HDA102.HDB102.T107]

- Adhering to organizational policies

- Following a documented plan and process description
- Applying adequate and appropriate resources (including funding, people, and tools)
- Maintaining appropriate assignment of responsibility and authority
- Training the people performing and supporting the process
- Placing work products under appropriate levels of configuration management
- Monitoring and controlling the performance of the process and taking corrective actions
- Objectively reviewing the process, its work products, and its services, and addressing noncompliance
- Reviewing the activities, status, and results of the process with appropriate levels of management, and taking corrective action
- Identifying and interacting with relevant stakeholders

Maturity Level 3: Defined

At maturity level 3, an organization has achieved all of the goals of the maturity level 2 and 3 process areas. Processes are tailored from the organization's set of standard processes and related organizational process assets to suit the circumstances in which they will be performed. At maturity level 3, processes are well characterized and understood, and are described in standards, procedures, tools, and methods. [FM122.HDA102.HDB103.T101]

Maturity level 3 process areas are Requirements Development, Technical Solution, Product Integration, Verification, Validation, Organizational Process Focus, Organizational Process Definition, Organizational Training, Integrated Project Management (IPPD), Risk Management, and Decision Analysis and Resolution. [FM122.HDA102.HDB103.T103]

The organization's set of standard processes, which are the basis for maturity level 3, are established and improved over time. These standard processes define the basic processes used for establishing consistent processes across the organization. [FM122.HDA102.HDB103.T104]

Basic processes describe the fundamental process elements that are expected at maturity level 3. Basic processes also describe the relationships (for example, the ordering and interfaces) between these process elements. The organization level infrastructure to support the current and future use of the organization's set of standard processes is established and improved over time. [FM122.HDA102.HDB103.T105]

The organization's management establishes process objectives based on the organization's set of standard processes. These process objectives are appropriately addressed at maturity level 3. [FM122.HDA102.HDB103.T106]

At maturity level 3, the following process characteristics are clearly stated: [FM122.HDA102.HDB103.T107]

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

At maturity level 3, institutionalization is achieved by doing the following: [FM122.HDA102.HDB103.T108]

- Satisfying the items that institutionalize a managed (maturity level 2) process
- Establishing the description of the defined process
- Establishing a plan based on the description of the defined process
- Performing the process according to the planned defined process
- Collecting work products, measures, and improvement information derived from performing the process
- Performing the process to support the future use and improvement of the organization's process assets

A critical distinction between maturity level 2 and maturity level 3 is the scope of application of the standards, process descriptions, and procedures. At maturity level 2, the standards, process descriptions, and procedures may be in use in only a 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 organizational process assets. As a result, the processes that are performed across the organization are consistent. [FM122.HDA102.HDB103.T109]

- Another critical distinction is that at maturity level 3, processes are described in more detail and more rigorously than at maturity level 2. At maturity level 3, processes are managed more proactively using an understanding of the interrelationships of the process

activities and detailed measures of the process, its work products, and its services.

Maturity Level 4: Quantitatively Managed

At maturity level 4, an organization has achieved all of the goals of the maturity level 2, 3, and 4 process areas. Processes are controlled using statistical and other quantitative techniques. Quantitative objectives for product quality, service quality, and process performance are established and used as criteria in managing processes. Product quality, service quality, and process performance are understood in statistical terms and are managed throughout the life of processes. [FM122.HDA102.HDB104.T101]

Maturity level 4 process areas are Organizational Process Performance and Quantitative Project Management. [FM122.HDA102.HDB104.T102]

Quantitative objectives are based on the needs of the customer, end-users, organization, and process implementors. Those performing the process are directly involved in quantitatively managing the process. [FM122.HDA102.HDB104.T103]

Processes that significantly contribute to overall process performance are quantitatively managed. For these processes, detailed measures of process performance are collected and statistically analyzed. Special causes of process variation[9] are identified and, where appropriate, the sources of special causes are corrected to prevent future occurrences. [FM122.HDA102.HDB104.T104]

Product quality, service quality, and process performance measures are incorporated into the organization's measurement repository to support fact-based decision-making in the future. [FM122.HDA102.HDB104.T106]

At maturity level 4, processes are institutionalized by doing the following: [FM122.HDA102.HDB104.T107]

- Satisfying the items that institutionalize a defined (maturity level 3) process
- Establishing and maintaining quantitative objectives for product quality, service quality, and process performance
- Establishing and maintaining a statistically stable and predictable process performance
- Establishing and maintaining a statistical understanding of the capability of the process to achieve the quantitative objectives for product quality, service quality, and process performance

[9] A special cause of process variation is a cause of a defect that is specific to some transient circumstance and not an inherent part of a process.

A critical distinction between maturity level 3 and maturity level 4 is the predictability of process performance. The performance of a process at maturity level 4 is controlled using statistical and other quantitative techniques, and is statistically predictable. At maturity level 3, processes are only qualitatively predictable. [FM122.HDA102.HDB104.T108]

At maturity level 4 the performance of processes include the following: [FM122.HDA102.HDB104.T109]

- Identifying and measuring product and process attributes that are important contributors to product quality, service quality, and process performance
- Identifying and addressing special causes of process variations (based on the selected product and process attributes)
- Bringing the performance of the process within its natural bounds (that is, make the process performance statistically stable and predictable based on the selected product and process ·attributes)
- Determining the capability of the process to satisfy established quantitative product quality, service quality, and process performance objectives
- Taking appropriate corrective actions when it is determined that the established quantitative product quality, service quality, and process performance objectives will not be satisfied

These actions may be limited to merely changing objectives or ensuring that stakeholders have a quantitative understanding of, and agree to, the performance shortfall. [FM122.HDA102.HDB104.T110]

Maturity Level 5: Optimizing

At maturity level 5, an organization has achieved all of the goals of the maturity level 2, 3, 4, and 5 process areas. Processes are continually improved based on an understanding of the common causes of variation[10] inherent in processes. [FM122.HDA102.HDB105.T101]

Maturity level 5 process areas are Organizational Innovation and Deployment and Causal Analysis and Resolution. [FM122.HDA102.HDB105.T103]

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. Both the processes and the organization's set of standard processes are targets of improvement activities. [FM122.HDA102.HDB105.T104]

[10] A common cause of process variation is the variation of a process that exists because of normal and expected interactions among the components of a process.

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. [FM122.HDA102.HDB105.T105]

Optimizing processes that are agile and innovative depend on the participation of an empowered workforce aligned with the business values and objectives of the organization. The organization's ability to rapidly respond to changes and opportunities is enhanced by finding ways to accelerate and share learning. Improvement of the processes is inherently part of everybody's role, resulting in a cycle of continual improvement. [FM122.HDA102.HDB105.T106]

Selected incremental and innovative technological process improvements are deployed into the organization systematically. The effects of the deployed process improvements are measured and evaluated against the quantitative process improvement objectives. [FM122.HDA102.HDB105.T107]

At maturity level 5, processes are institutionalized by doing the following: [FM122.HDA102.HDB105.T108]

- Satisfying the items that institutionalize a quantitatively managed (maturity level 4) process
- Establishing and maintaining quantitative process improvement objectives
- Identifying and deploying both incremental and innovative technological improvements that continually improves the range of process performance

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 for 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, shift the mean of the process performance) to improve process performance (while maintaining statistical predictability) to achieve the established quantitative process improvement objectives. [FM122.HDA102.HDB105.T109]

Common Features

Common features are predefined attributes that group generic goals and 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. Generic goals signify whether the implementation and institutionalization of each process area are effective, repeatable, and lasting. [FM122.HDA103.T101]

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

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

In the process areas, generic practices appear after the last goal, grouped by the common features. Generic practice elaborations also appear in each process area to provide guidance on how the generic practices should uniquely be applied to the process area. [FM122.HDA104.T101]

Although this information is applied throughout the model in multiple process areas, the entire text of each generic practice is not repeated in every process area. Instead, the generic practice titles and statements appear alone in each process area. As you apply generic practices within each process area, refer to this section for the details of these practices, such as subpractices and work products.[11] [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 apply to process areas at maturity levels 3 through 5. [FM122.HDA104.T104]

[11] The generic practices that apply to the staged representation appear in this chapter. There are other generic practices that are used only by the continuous representation. These capability level 1, 4, and 5 generic practices are found in chapter four of the continuous representation.

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 practice is to define the organizational expectations for the process and make these expectations visible to those in the organization who are affected. [GP103]

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

Ability to Perform

GP 2.2 Plan the Process

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

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

Requirements are defined for the process's specified work products and for performing the work. [GP104.N101]

The objectives for the process are established by those responsible for performing the process. Included are objectives for their specific situation, including quality, cost, and schedule objectives. For example, an objective might be to reduce the cost of performing a process for this implementation over the previous implementation. [GP104.N102]

Establishing a plan includes documenting it. Maintaining the plan includes changing it, as necessary, as a result of corrective actions, changes to the process, and changes to the requirements and objectives for the process. [GP104.N103]

In some CMMI process areas there are specific practices that also talk about developing strategies or plans. This generic practice addresses overall planning for the entire process area, whereas the specific practices address a topic for more detailed or focused planning. [GP104.N104]

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 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 standalone 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]

   The plan for performing the process typically covers the following: [GP104.SubP103.N101]

   - 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)
   - Schedule (events and activity dependencies) for performing the process
   - Dependencies among the activities, work products, and services of the process
   - Resources (including funding, people, and tools) needed to perform the process
   - Assignment of responsibility and authority
   - Training needed for performing and supporting the process
   - 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
   - Activities for monitoring and controlling the process
   - Objective verification activities for the process and the work products
   - Management review activities for the process and the work products

4. Review the plan with 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 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 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 a plan for the process. Dynamic assignment of responsibility is another legitimate way to perform this practice, as long as the assignment and acceptance of responsibility is assured 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 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]

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

GP 3.1 Establish a Defined Process

Establish and maintain the description of a defined process.

The purpose of this 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. 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 standard set of 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 the standard process that best fits the specific instantiation from the organization's set of standard processes. [GP114.SubP101]
2. Establish the defined process by tailoring the selected standard processes and other process assets 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 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. *[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 development 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. [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 practice is to establish and maintain the expected involvement of stakeholders during the execution of the process. [GP124]

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

Involve stakeholders as described in an appropriate plan for stakeholder involvement (e.g., as developed in the Project Planning PA). Involve them appropriately in activities such as: [GP124.N101]

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

The objective of planning the stakeholder involvement is to assure 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]

   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. Get stakeholders involved as planned. [GP124.SubP103]

GP 2.8 Monitor and Control the Process

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

The purpose of this 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. [GP110]

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

Subpractices

1. Measure actual performance against the plan. [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. [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. [GP110.SubP104]

5. Identify problems in the process and in the plan. [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. [GP110.SubP106]

   There are inherent risks that need to 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
   - Adjusting resources, including people, tools, and other resources
   - Negotiating changes to the established commitments
   - Securing change to the requirements and standards that have to be satisfied
   - Terminating the effort

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 practice is to collect information and artifacts derived from planning and performing the process. This practice is performed so that the information and artifacts can be included in the organization's 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 organizational measurement repository and the organizational library of process-related assets. [GP117]

Refer to the Organizational Process Definition process area for more information about the organizational measurement repository and library of process-related assets. *[GP117.R101]*

Subpractices

1. Store process and product measures in the organizational measurement repository. [GP117.SubP102]

   The process and product measures are primarily those that are defined in the organization's common set of measures for the set of standard processes. [GP117.SubP102.N101]

2. Submit documentation for inclusion in the organizational library of process-related assets. [GP117.SubP103]

3. Document lessons learned from the process for inclusion in the organizational library of process-related assets. [GP117.SubP104]

4. Propose improvements to the organization's process assets. [GP117.SubP101]

Verifying Implementation

GP 2.9 Objectively Evaluate Adherence

Objectively evaluate adherence of the process and the work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance.

The purpose of this practice is to provide credible assurance that the process is implemented as planned and satisfies the relevant policies, requirements, standards, and objectives. [GP113]

Refer to the Process and Product Quality Assurance process area for more information about the specific goal and practices needed to objectively evaluate adherence. *[GP113.R101]*

People not directly responsible for managing or performing the activities of the process typically evaluate adherence. 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]

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 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 sponsorship 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 Understanding the Model

The CMMI Product Suite represents a consensus-based approach to identifying and describing best practices in a variety of disciplines. This model is a tool used to reasonably interpret the CMMI practices when you apply them to your organization. [FM102.T101]

Successful process improvement initiatives must be driven by the business objectives of the organization. Process improvement objectives are derived from the business objectives. In turn, process objectives are dependent on the processes the organization wishes to improve. [FM102.T102]

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. Finally, the process objectives applied from the CMMI model would be those found in the Project Planning and Project Monitoring and Control process areas. [FM102.T103]

Four Categories of CMMI Process Areas

Besides categorizing process areas by maturity level, you can also group all process areas into four categories: [FM102.HDA101.T102]

- Process Management Processes
- Project Management Processes
- Engineering Processes
- Support Processes

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 structured decision making practices 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.T104]

The Engineering process areas are written in a general engineering terminology so any technical discipline involved in the product development process (for example, 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.T106]

Whether you use a model with a staged or continuous representation, you must be aware of the interactions that exist among the CMMI model components to apply the model in a useful and productive way. The following sections describe the interactions that occur among CMMI model components. [FM102.HDA101.T107]

Process Management Processes

The Scope of Process Management Processes

Process management process areas contain the cross-project practices related to defining, planning, resourcing, deploying, implementing, monitoring, controlling, verifying, measuring, and improving processes. The process management process areas of CMMI are as follows: [FM102.HDA102.HDB101.T101]

- 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.T102]

- 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, 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. [FM102.HDA102.HDB102.T102]

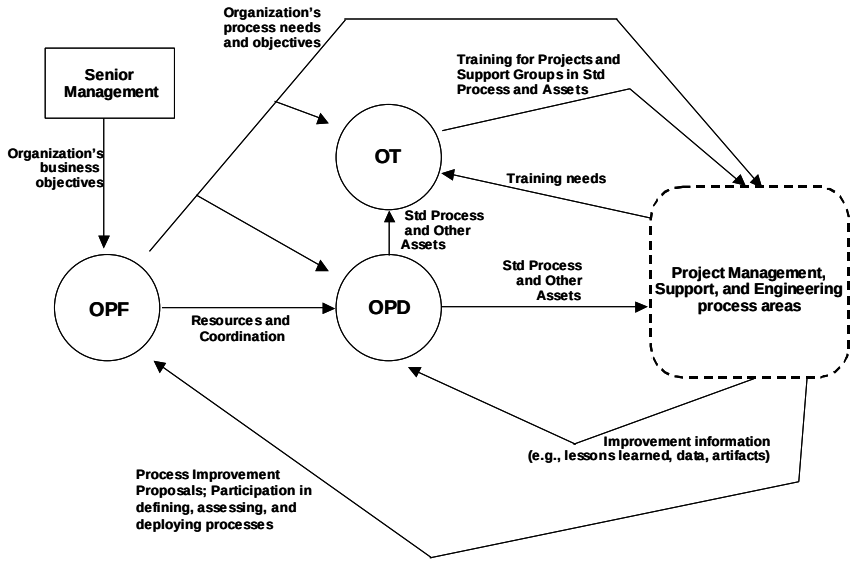

Figure 2: Basic Process Management Process Areas

[FM102.HDA102.HDB102.T103]

As illustrated in Figure 2, the Organizational Process Focus process area helps the organization establish and maintain an understanding of its processes and identify, plan, coordinate, and implement improvement. 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 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 supporting assets based on the organizational process needs and objectives of the organization. These process and supporting assets include descriptions of processes and process elements, descriptions of life-cycle models, process tailoring guidelines, process related documentation, and data. The organization's set of standard processes is tailored by projects and support groups to create their defined processes. The other process and support 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 supporting assets. [FM102.HDA102.HDB102.T105]

IPPD standard processes and guidelines are included in the organization's process asset library, which is established and maintained in the Process Management process areas. These IPPD processes and guidelines require integrated processes that ensure that product-related life-cycle processes (such as manufacturing, code development, testing, deployment, training, and other support needs) are identified and planned concurrently with the product design. These integrated processes should also address relevant stakeholder involvement, customer satisfaction, and a continuous focus on the product life cycle. [FM102.HDA102.HDB102.T106]

In an IPPD environment, product development processes shift emphasis from serial development to parallel collaborative development and the integration of the product set that includes all the products, services, and processes for the life cycle of the product. The tailoring of the organization's set of standard processes to IPPD guidelines and the addition of IPPD standard processes establishes the extent of process development that occurs concurrently with the product development on projects. For example, if the organization has a standard process for manufacturing a certain type or family of product components, then that process does not need to be redeveloped, but rather is tailored as the product is designed. The recommended process development decision in that case is to reuse and modify an existing process. [FM102.HDA102.HDB102.T107]

The Organizational Training process area identifies the strategic training needs of the organization as well as 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. 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. [FM102.HDA102.HDB103.T102]

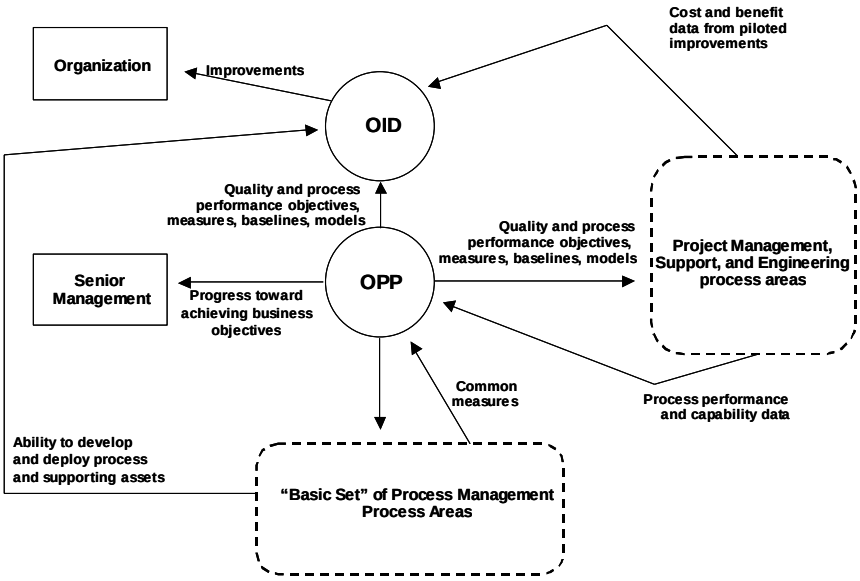

Figure 3: Advanced Process Management Process Areas

[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]

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 requires 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]

The Scope of Project Management Processes

Project management process areas cover the project management activities related to planning, monitoring, and controlling the project. The project management process areas of CMMI are as follows:

[FM102.HDA103.HDB101.T102]

- Project Planning
- Project Monitoring and Control
- Supplier Agreement Management
- Integrated Project Management (IPPD)
- 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 (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 areas.

[FM102.HDA103.HDB102.T102]

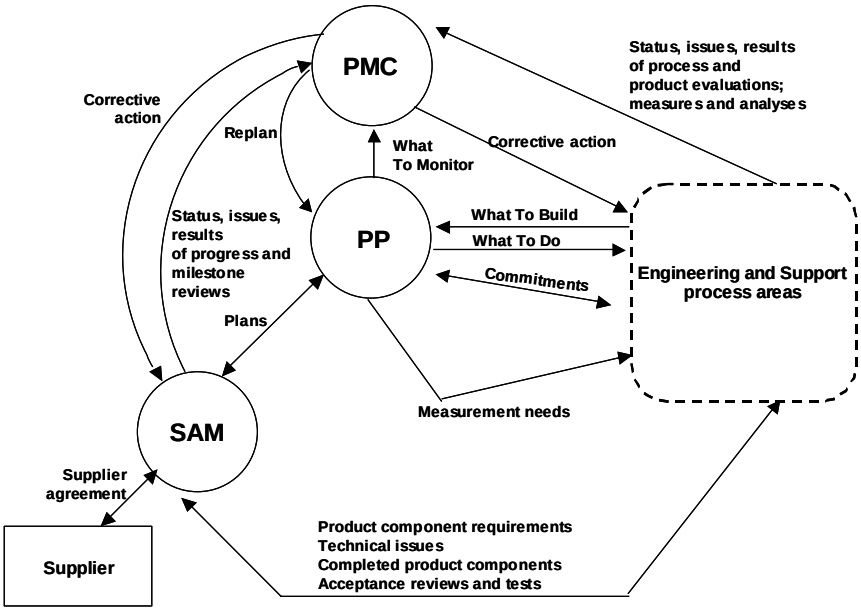

Figure 4: Basic Project Management Process Areas

[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. In an IPPD environment, 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]

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 subordinate plans from various support groups and establish commitments with those groups for their contributions to the project. These support group plans cover process and 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 select and manage 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. 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.) [FM102.HDA103.HDB103.T103]

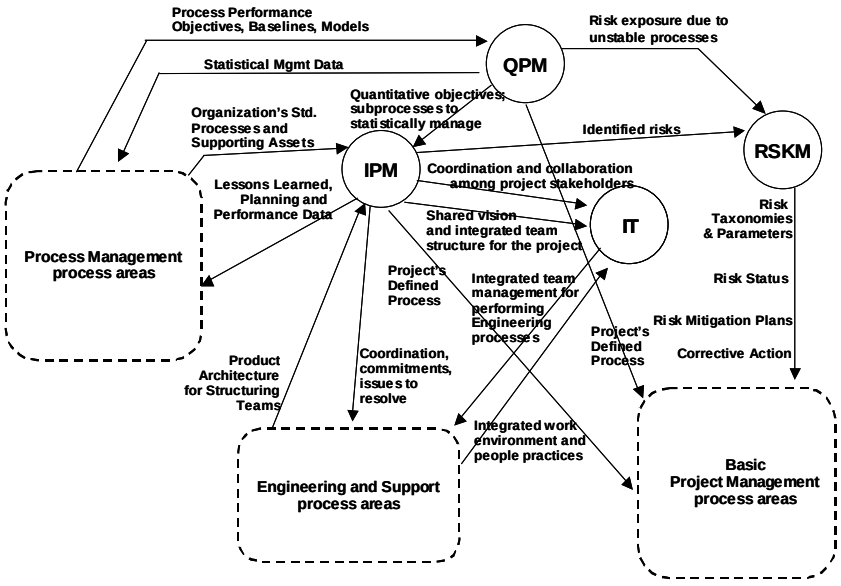

Figure 5: Advanced Project Management Process Areas

[FM102.HDA103.HDB103.T105]

As illustrated in Figure 5, the Integrated Project Management (IPPD) process area establishes and maintains 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 and supporting assets. It also ensures that the principles of IPPD are incorporated into project planning and the project's defined process, and that the useful measures and process fragments developed when using the IPPD approach are included in 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 the stakeholders. These activities are all part of the cultural environment needed for implementation of IPPD. [FM102.HDA103.HDB103.T110]

The Integrated Project Management (IPPD) process area also creates the shared vision for the project. This shared vision needs to align both horizontally and vertically with both the organization and integrated team shared vision, created in the Organizational Environment for Integration and Integrated Teaming process areas, respectively. These shared visions collectively support the coordination and collaboration among stakeholders. Lastly, the Integrated Project Management (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 a 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 continuous, forward-looking approach to managing risks with activities that include identification of risk parameters and taxonomies; 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 established in the Integrated Project Management (IPPD) is comprised, in part, of 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 variation[12] are identified. [FM102.HDA103.HDB103.T114]

While the integrated team structure is established within the Integrated Project Management (IPPD) process area, the practices in the Integrated Teaming process area provide for the formation and sustainment of each integrated team in this structure. Part of sustaining the team is developing the integrated team's shared vision, which must align with the project and organization shared vision, developed in Integrated Project Management (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 effecting the integrated teamwork for completing projects. 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]

Engineering Processes

The Scope of Engineering Processes

Engineering process areas cover the development and maintenance practices that are shared across engineering disciplines (for example, systems engineering and software engineering). The six engineering process areas 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]

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

- Requirements Development
- Requirements Management

[12] A special cause of process variation is a cause of a defect that is specific to some transient circumstance and not an inherent part of a process.

- 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 “stove-pipe” 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 product life cycle, such as that provided in the engineering process areas of the CMMI-SE/SW model. Thus, the implementation of the IPPD environment provides amplifications to specific practices in the Engineering process areas that emphasize the concurrent development and life-cycle focus. [FM102.HDA104.HDB102.T102]

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

Figure 6 provides a bird’s-eye view of the interactions among all engineering process areas. [FM102.HDA104.HDB102.T104]

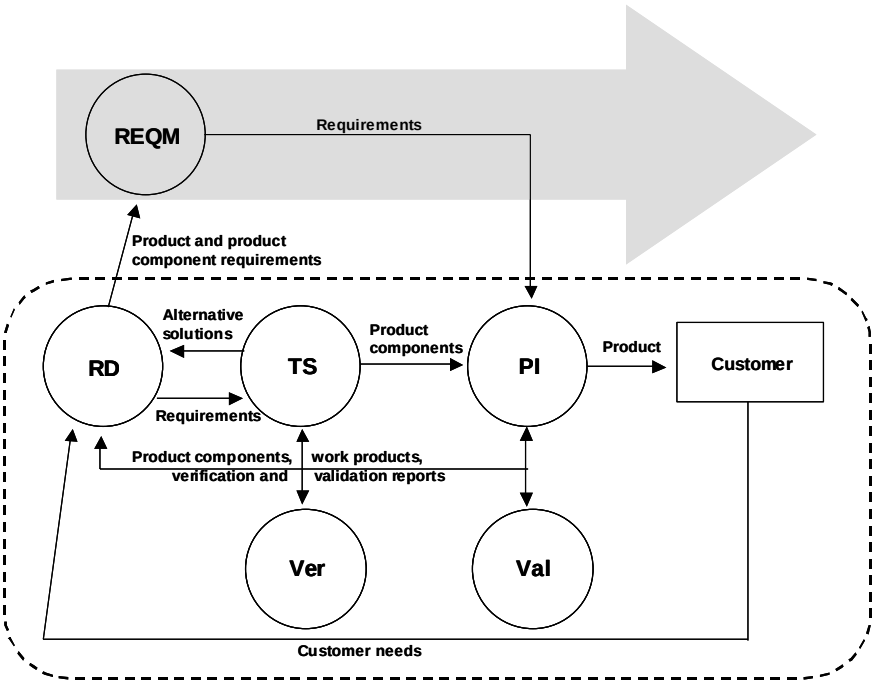

Figure 6: Engineering Process Areas *[FM102.HDA104.HDB102.T106]*

The development of a product or service starts with the needs, expectations, and constraints of a customer. 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 entails decomposition (sometimes in multiple levels) until an appropriate level is reached at which point, discipline-specific product components are identified. [FM102.HDA104.HDB102.T107]

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 what the product's performance, design features, verification requirements, and so on, are in terms the developer understands and uses. [FM102.HDA104.HDB102.T109]

The translation of customer needs into product requirements involves the simultaneous evolution of a preliminary functional architecture. This preliminary functional architecture assigns product requirements to functional entities; thus starting the functional decomposition necessary to eventually describe the product to be developed. [FM102.HDA104.HDB102.T110]

The Requirements Development process area also supplies requirements to Technical Solution, where the requirements are converted into the product architecture, product component design, and the product component itself (for example, coding, fabrication). This information is fed to Product Integration, where product components are combined and interfaces are assured to meet the interface requirements supplied by Requirements Development. [FM102.HDA104.HDB102.T111]

The Requirements Management process area maintains the requirements. It describes practices for obtaining and controlling requirement changes, and ensuring other relevant plans and data are kept current. 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 product component technical data packages and implements 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 practices in the Decision Analysis and Resolution process area. [FM102.HDA104.HDB102.T114]

The Technical Solution process area relies on the 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 expects that a verification strategy is developed to ensure adequate verification. This verification strategy should be highly integrated with the Technical Solution process area and the Product Integration process area. It is generally an incremental process starting with product component verification and usually concludes with verification of fully assembled products. [FM102.HDA104.HDB102.T116]

Verification also addresses peer reviews. Peer reviews are a proven method of defect reduction in product development and maintenance and provides valuable insight into the work products and product components being developed and maintained. [FM102.HDA104.HDB102.T117]

The Validation process area 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 and the validation strategy 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, and processes. The product, product component, or process may often require re-verification and re-validation and is therefore tightly coupled to the other engineering process areas. 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 practices associated with generating the best possible integration strategy, integrating product components and delivering the product to the customer. [FM102.HDA104.HDB102.T120]

Product Integration uses the 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 practices of the Validation process area are used. [FM102.HDA104.HDB102.T121]

Product Integration addresses the testing needed to ensure proper functional performance and acceptable physical attributes. After acceptance testing the product is properly packaged and shipped. [FM102.HDA104.HDB102.T122]

Engineering Process Areas and Recursion

All engineering process areas have been written to support recursion of the process(es) throughout the product architecture. There is no specific practice that forces recursive process application. Rather, the practices are written in a fashion that "expects" process application throughout the product architecture. You may be more comfortable viewing the 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 view is appropriate. [FM102.HDA104.HDB103.T101]

There are a number of advantages gained by this generality. For example, the engineering process areas can be applied to a product that has several layers of product components that address each layer. Thus, different segments of a very large project can be assessed using the same model. [FM102.HDA104.HDB103.T102]

Support Processes

The Scope of Support

Support process areas cover the practices that support product development and maintenance and the establishment and maintenance of a work environment that facilitates and stimulates integration and manages people to enable and reward integrative behaviors. The support process areas of CMMI are as follows: [FM102.HDA105.HDB101.T102]

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

The support process areas provide essential processes that are used by all of the CMMI process areas and are typically used in the context of performing other processes. In general the support process areas are targeted towards the project (except for Process and Product Quality Assurance and Organizational Environment for Integration) but can be applied more generally to the organization. For example, Process and Product Quality Assurance can be used with all the process areas to provide an objective review of the processes and work products described in all of the process areas. [FM102.HDA105.HDB101.T104]

Basic Support Process Areas

The basic support process areas address basic support functions that will be used by all of the process areas. Although all support process areas rely on the other process areas in the CMMI model for inputs, all of 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 basic Support process areas’ interactions. [FM102.HDA105.HDB102.T102]

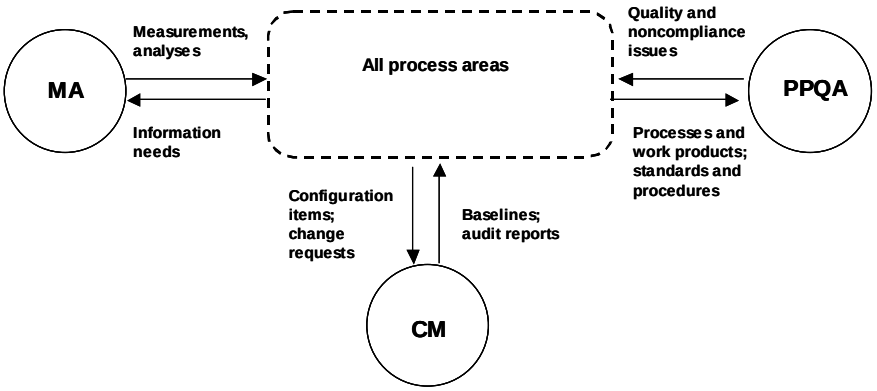

Figure 7: Basic Support Process Areas *[FM102.HDA105.HDB102.T104]*

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

[FM102.HDA105.HDB102.T105]

The Process and Product Quality Assurance process area supports all process areas by providing 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 cycle.

[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 rely on specific inputs or practices from other process areas. [FM102.HDA105.HDB103.T101]

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

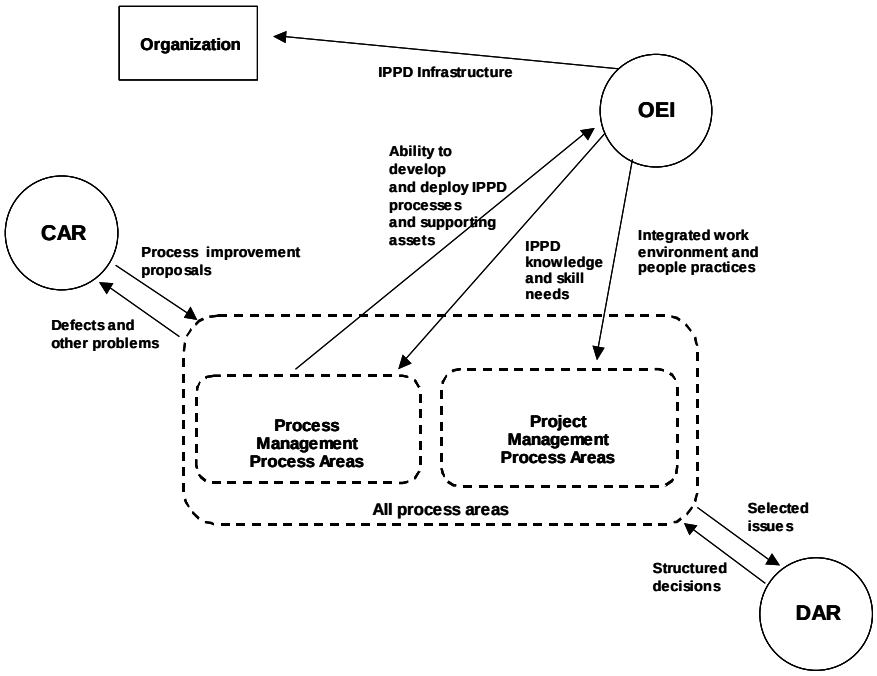

Figure 8: Advanced Support Process Areas [FM102.HDA105.HDB103.T105]

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.T106]

Using the Causal Analysis and Resolution process area, the project strives to understand the common causes of variation inherent in the process 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 structured decision-making 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]

6 Using the Model

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 assessment methods, and common training materials. The objective is to reduce the cost of establishing and maintaining effective process improvement efforts across an enterprise using multiple disciplines to produce its products or services. This chapter describes how organizations may use the model for both process improvement and benchmarking. [FM120.T101]

Interpreting the Model

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 and maintaining products and services. While a new enterprise might wish to establish its processes using these concepts, it is most common to find organizations already doing business, but seeking to improve their process methodology. [FM120.HDA101.T101]

Such organizations should use professional judgment to interpret CMMI practices. Although process areas depict behavior that should be exhibited in any organization, practices must be interpreted using an in-depth knowledge of the CMMI model, the organization, the business environment, and the specific circumstances involved. [FM120.HDA101.T102]

CMMI practices purposely use nonspecific phrases such as “relevant stakeholders,” “as appropriate,” and “as necessary” to meet the needs of different organizations or projects. Specific needs may also differ at various points in a single project’s development life cycle. [FM120.HDA101.T103]

To interpret practices, it is important to consider the overall context in which they are used and how well the practices satisfy the goals of a process area within that context. The CMMI model does not prejudge which processes are right for the organization or project. Instead, it establishes minimal criteria that processes must meet to be considered capable. [FM120.HDA101.T104]

A capable process is defined, documented, practiced, supported, maintained, controlled, verified, validated, measured, and able to be improved. [FM120.HDA101.T105]

The CMMI models have resulted from studying the practices and needs of highly structured, large, and complex projects. While they are also appropriate for smaller organizations, some of the processes described in the model will not suit the needs of smaller companies or projects without tailoring or interpretation. For example, in a small organization the processes performed by a "group" in the model may instead be the responsibility of a single individual. [FM120.HDA101.T107]

Assessing for Process Improvement and Benchmarking

Process assessments 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. Assessment teams use the 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 an engineering process group, for example) to plan an improvement strategy 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 assess multiple disciplines (for example, software engineering and system engineering), the unified CMMI approach permits some economy of scale in model training and assessment training. One assessment method can provide separate or combined results for multiple disciplines. [FM120.HDA102.T102]

Alternatively, an organization may wish to use, for example, a limited Class B or C assessment method[13] with the continuous representation to focus on individual process areas of most significant business value. It might then employ a Class A staged Standard CMMI Assessment Method for Process Improvement (SCAMPI) on a less frequent basis to benchmark the entire organization. [FM120.HDA102.T103]

The CMMI assessment products will also allow the assessment of a single discipline, as in the past. CMMI assessment products provide consistent findings for staged and continuous representations with equivalent staging. [FM120.HDA102.T105]

The assessment principles for the CMMI Product Suite remain the same as those used in past assessments using the SW-CMM and the Systems Engineering Capability Model (SECM): [FM120.HDA102.T106]

[13] See Assessment Requirements for CMMI (ARC) and Standard CMMI Assessment Method for Process Improvement (SCAMPI) for more information about classes of assessment methods.

- senior management sponsorship
- a focus on the organization's business objectives
- confidentiality for interviewees
- use of a documented assessment 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 assessment techniques is expected to be available. New techniques will be developed and existing ones improved to meet various needs for building internal improvement and external confidence. The CMMI project has produced one method to meet the need for a rigorous assessment tool for benchmarking and a set of guidelines for future additions to the suite for other process improvement assessments requiring less rigor and repeatability. This first and most rigorous version has been named the Standard CMMI Assessment Method for Process Improvement, or SCAMPI. Details on this method are available on the Software Engineering Institute Web site. [FM120.HDA102.T107]

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

SCAMPI was written to conform to the emerging International Organization for Standardization and the International/Electrotechnical Commission (ISO/IEC) 15504 technical report. 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 a ISO/IEC 15504-conformant assessment, SCAMPI will support these needs. [FM120.HDA102.T109]

Assessment Requirements for CMMI

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

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

The ARC was designed to help improve consistency across multiple disciplines and assessment methods, and to help assessment method developers, sponsors, and users understand the trade-offs associated with various methods. More information and a matrix detailing ARC requirements is available on the Software Engineering Institute Web site. [FM120.HDA102.HDB101.T103]

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

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 SECM or the Software CMM. 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

Most 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 organizational and life-cycle coverage afforded in the CMMI model. Many of these organizations will need to decide the best timing for transition to preserve the value of plans toward, for example, a particular maturity level achievement. [FM120.HDA103.HDB102.T105]

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 the CMMI model. These organizations will find strong commonality between this and the heritage model. There is also significant improvement in coverage of the engineering dimension, more detailed coverage of risk management and measurement, and analysis that was less specific in the Software CMM. [FM120.HDA103.HDB102.T102]

The practices at 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 level 4 and 5 practices by leading organizations. [FM120.HDA103.HDB102.T103]

Organizations that have begun significant movement toward a maturity level 2, 3, or 4 assessment must weigh the costs of making the transition against the benefits of the improved coverage the 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 assessment strategy. If the costs of total transition appear high, an interim strategy might be to augment the current plan with selected process areas of greatest business value. [FM120.HDA103.HDB102.T106]

For example, a company with several months remaining before a maturity level 4 assessment might want to charter small teams to investigate Risk Management and Measurement and Analysis, and add them to the assessment scope to begin the transition without affecting current efforts. This strategy allows members of the organization to have a “first look” at new process areas to gain insight that helps them build business value in these two key areas as well as preparing them for future CMMI assessments. [FM120.HDA103.HDB102.T107]

Organizations with SECM 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. The process capability focus of this set of models makes transition choices more varied than if multiple process areas were spotlighted as in the SW-CMM. [FM120.HDA103.HDB103.T101]

The evolution from EIA/IS 731 involves both: (1) some reorganization of specific practices under goals and process areas and (2) the addition of informative material. Initial transition steps therefore might be to compare current specific practice improvement efforts against those now expected in the CMMI models. [FM120.HDA103.HDB103.T102]

Organizations Without Experience in Either Model

Organizations without experience in either model are assumed to be in one of two categories. They may have process improvement efforts under other quality initiatives such as ISO 9000 or Malcolm Baldrige; or they may be considering such efforts due to 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 this Product Suite. They also gain a reference model of effective practices that can be applied—across the value chain—to enhance the development of software-intensive products and associated services. [FM120.HDA103.HDB104.T102]

These organizations might wish to begin by considering whether approaching improvement is better served by emphasizing process capability or organizational maturity. Each approach is complementary. A focus on process capability allows the building of organizational maturity, and a focus on organizational maturity allows concentration on particular process capabilities. Neither is mutually exclusive, but the choice will determine which representation will best fit the needs of the organization for training and assessment. [FM120.HDA103.HDB104.T103]

Once your organization has decided which representation is the best fit, planning can begin with an improvement strategy such as the IDEAL (initiating, diagnosing, establishing, acting, leveraging) model. Research has shown that the most powerful initial step to process improvement is to build a strong organizational sponsorship during an initiating phase prior to significant diagnostic efforts. [FM120.HDA103.HDB104.T104]

Given sufficient senior management sponsorship, establishing a specific, technically competent 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 selected other membership based on the business needs driving improvement. For example, a systems administrator focused on Information Technology support and a marketing representative concerned with integrating customer needs could make powerful additions to the engineering process group (EPG). [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 will be provided by the SEI and its transition partners, your organization may wish to supplement these courses with internal instruction. This approach allows the focus of organizational attention to be placed on the areas marked for greater attention due to the linkage to the product development value chain. [FM120.HDA103.HDB105.T101]

Initial training will be available for both representations of CMMI models, with additional training provided to assist those who will need to guide improvement on the EPG, or those seeking to become lead assessors. [FM120.HDA103.HDB105.T102]

Tailoring Criteria

Tailoring the CMMI model is a process whereby only a subset of the model is used to make it suitable for a specific application. [FM120.HDA104.T101]

Tailoring the CMMI assessment method is the selection of options for use in a specific assessment. In both cases, the intent of tailoring is to assist an organization or project in aligning the CMMI products with its business needs and objectives, and thus focus on those aspects of the products and services that are most beneficial to the organization. [FM120.HDA104.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 and is further addressed in the Integrated Project Management (IPPD) process area. [FM120.HDA104.T104]

Tailoring should be done knowing that it can result in significant gaps in efforts to improve or assess an organization's or project's capabilities. [FM120.HDA104.T105]

Model Tailoring Perspectives

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

- Tailoring related to use of the model for process improvement
- Tailoring related to use of the model for benchmarking

Many organizations will use the model for benchmarking as well as process improvement, so the appropriate tailoring will be constrained by the intersection of criteria outlined below. [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 assessments). The tailoring may address individual disciplines, process areas, maturity levels, and/or capability levels. Tailoring of the model should focus on identifying the process areas and practices that support the business needs and objectives. [FM120.HDA104.HDB102.T101]

Care must be taken when considering tailoring out portions of the model. Given the model's focus on the essential characteristics of an effective process, the majority of the process areas and practices in the model typically would be addressed. In fact, the folly of wholesale exclusion of fundamental processes and/or practices (in particular at maturity levels 2 and 3) is clear given the prevalence of data indicating that following CMM-based improvement efforts will significantly improve attainment of business objectives. Cited improvements in the literature include the increased likelihood that an organization or project will achieve its cost and/or schedule objectives. [FM120.HDA104.HDB102.T102]

Organizations and/or projects implementing less than a full set of process areas, goals, or practices can still achieve significant value from the CMMI model. However, due to the significant interrelationship of model components, exclusion of a significant number of process areas, goals, and/or practices may constrain the benefits achieved. In addition, the degree of comparability of assessment results is directly related to the extent to which the model and assessment method have been tailored. [FM120.HDA104.HDB102.T103]

Model Tailoring Criteria for Benchmarking

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

Keep in mind that the disciplines chosen for an assessment also affects the context of benchmarking. If one organization chooses to assess only software engineering while another chooses to assess 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 components and thus may not be excluded (that is, tailored out) other than to delete those that are outside the scope of an assessment. For example, process areas at maturity levels 4 and 5 may be omitted for an assessment focused on maturity level 3, where all process areas for levels 2 and 3 would typically be selected.
- Process areas, in some unique circumstances, may be determined to be ”not applicable” if the process area is, in fact, outside of the organization’s scope of work. Typically, very few process areas are eligible for exclusion in this manner. An example of a process area that might be excluded would be Supplier Agreement Management, a process area that may be inapplicable in the absence of suppliers of products and services external to the organization that are critical to the development effort. A maturity level rating could still be determined, with the identification of the “not applicable” process area.
- A process area is designated as “not rated” if it is outside of the assessment scope or if insufficient data is available to satisfy the data coverage criteria. A maturity level cannot be determined if process areas at that level (or below) are “not rated.”
- Goals, are required and thus are not excluded from those process areas included in the scope of a process improvement or assessment effort. Goals reflect the minimum requirements for satisfying a process area at their defined capability levels. If a process area is applicable, each of its goals is applicable at defined capability levels. 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 or capability levels. 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. Infrequently, a specific practice may be determined during an assessment to be "not applicable" and thus excluded from coverage.

- 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 3- to 6-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 member projects. [FM120.HDA104.HDB104.T101]

Conversely, in the project plan, the details of what the project is developing, the development process, the schedule, and staff assigned to each task are defined. Often this plan also captures the development plan, quality assurance plan, and configuration management plan. A four-person project development group might expect to develop a five-page project plan. Dynamic parts of the plan, such as the schedule and list of deliverables are in the plan's appendix. [FM120.HDA104.HDB104.T102]

Project specifics, such as special customer requirements, may be covered in the project plan. Usually, the bulk of the project plan is a detailed schedule in which resources are assigned and tracked. The global development and test environment, quality assurance review process, configuration management, delivery processes, and customer and internal review processes are in the higher-level management plan. [FM120.HDA104.HDB104.T103]

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. A configuration management function keeps every version of the schedule in the project library. [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 they have decided on an approach, it should be captured in the project plan details, and communicated to the customer. [FM120.HDA104.HDB104.T105]

The work of a small team may be highly collaborative; thus, a formal peer review may not provide a high return on investment. The checklist for the review by a peer is just as comprehensive in this small team approach as it would be for a larger team. All of the standards are enforced by all of the members of the team. [FM120.HDA104.HDB104.T106]

Periodically, reviews of the project plans and lessons learned may be funneled to a higher-level of the organization. This review ensures that the higher level documentation and direction is continually improved. Best business practices are identified and fed back into the organization's process asset library, and the organizational processes, plans, and templates are modified to reflect the improvements used by the project. The next time the project begins work with a new set of requirements, it tailors the updated organizational assets.
[FM120.HDA104.HDB104.T107]

Assessment Tailoring Criteria

The major tailoring options for a CMMI assessment include:
[FM120.HDA104.HDB105.T101]

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

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

Refer to the Model Components section of the Structure of the Model chapter of the Overview for more information about CMMI maturity levels. *[FM109.T101.R101]*

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

The term "requirements" refers to product and product component requirements that are received by or generated by the project, including those requirements levied on the project by the organization. The requirements are both technical and non-technical. The practices in the Requirements Management process area are the source for the current, approved set of requirements upon which all of the practices in the other project process areas act. [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. After agreement between the requirements provider and the requirements receiver, commitment to the requirements is obtained from the project participants who have to do project activities and implement the requirements. The project manages changes to the requirements as they evolve during the project and identifies any inconsistencies that occur between the plans and work products and the requirements. [PA146.N102]

Part of the management of requirements is to capture requirements changes and rationale and maintain bi-directional traceability among source requirements and all product and product component requirements. [PA146.N103]

This process area is tightly coupled with the Requirements Development and the Technical Solution process areas, which address the processes for transforming stakeholder needs into product requirements and deciding how to allocate or distribute requirements among the product components. The practices in the Requirements Management process area should be done concurrently with the practices in the Requirements Development process area and the Technical Solution process area when those practices are implemented. [PA146.N104]

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 baselining 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. *[PA146.R105]*

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.

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 Bi-directional Traceability of Requirements
SP 1.5		Identify Inconsistencies between Project Work and Requirements

GG 2 Institutionalize a Managed Process

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

Specific Practices by Goal

SG 1 Manage Requirements [PA146.IG101]

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

The goal is to provide the project with a current, approved set of requirements over the life of the project, manage all changes to the requirements, make sure the relationships between the requirements and other entities affected by the requirements are captured bi-directionally and identify inconsistencies between the set of requirements and the project plans and work products. Identified inconsistencies then generate corrective actions. [PA146.IG101.N101]

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]*

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 or "leakage," 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. Lists of criteria for establishing an understanding [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]

Examples of criteria are as follows: [PA146.IG101.SP101.SubP102.N101]

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

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

4. Reach an understanding of the requirements with the requirements provider sufficient 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 practice dealt with reaching an understanding with the requirements provider, this 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 during the activities of the Requirements Development process area and the Technical Solution process area. As the requirements evolve, a commitment to the current, approved requirements and the subsequent changes in project plans, activities, and work products are required among all relevant stakeholders. [PA146.IG101.SP102.N101]

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. Record the commitment. [PA146.IG101.SP102.SubP102]

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 Bi-directional Traceability of Requirements

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

The intent of this specific practice is to maintain the bi-directional traceability of requirements for each level of product decomposition. When the requirements are managed well, traceability can be established from the source requirement to its lower-level requirements and from the lower-level requirements back to their source. Such bi-directional traceability helps determine that all source requirements have been completely addressed and that all lower-level requirements can be traced to a valid source. Requirements traceability can also cover the relationships to other entities such as the product, changes in design documentation, test plans, verifications, validations, and work tasks. The traceability should cover the horizontal as well as the 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 captured. [PA146.IG101.SP104.SubP101]
2. Maintain requirements traceability from a requirement to its derived requirements and the allocation to functions, objects, people, and processes. [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. *[PA146.IG101.SP105.R101]*

Although some work products resulting from this activity would be updated project plans, activities, and work products, these are products of the Project Planning process area, not Requirements Management. This 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, rationales [PA146.IG101.SP105.W101]
2. Corrective action requirements [PA146.IG101.SP105.W102]
3. Corrective action [PA146.IG101.SP105.W103]

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 requirements and objectives, and plans for performing the requirements management process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are typically described in 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 tools used in performing the activities of the Requirements Management process area include the following: [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

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:

For engineering processes, consider stakeholders among 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 bi-directional traceability
- Identifying inconsistencies between project work and requirements

GP 2.8 (DI 3) Monitor and Control the Process

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

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Requirements Management process area 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 and the work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance. *[GP113]*

Elaboration:

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

- Managing requirements
- Identifying inconsistencies between the project plans and work products and the 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]*

PROJECT PLANNING

Maturity Level 2

Purpose

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

Introductory Notes

Project Planning includes developing the project plan, interacting with stakeholders appropriately and getting commitment to the plan, and maintaining the plan. [PA163.N101]

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

Planning includes estimating the attributes of the work products and tasks, 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. Activities describing both planning and re-planning are contained in this process area. [PA163.N104]

The term "project plan" is used throughout these practices 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]*

Refer to the Measurement and Analysis process area for more information about the planning required for project progress and performance measurement. *[PA163.R105]*

Refer to the Supplier Selection and Monitoring for more information about the planning needs for managing an acquisition. *[PA163.R106]*

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.

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 Project 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 Subordinate Plans
- SP 3.2 Reconcile Work and Resource Levels
- SP 3.3 Obtain Plan Commitment

GG 2 Institutionalize a Managed Process
- 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

Specific Practices by Goal

SG 1 Establish Estimates [PA163.IG101]

Estimates of project planning parameters are established and maintained.

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 expectations from the project
- Identified tasks and work products
- Technical approach
- Attributes of the work products and tasks (e.g., size or complexity)
- 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 the review and commitment of stakeholders 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 and maintain a top-level work breakdown structure (WBS) to estimate of 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. 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 product descriptions [PA163.IG101.SP101.W102]
3. Work Breakdown Structure [PA163.IG101.SP101.W103]

Subpractices

1. Develop a WBS structure 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 life-cycle management of non-developmental items

2. Identify the work products in sufficient detail to specify estimates of the 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 level of understanding of the WBS at this point in time will help in developing realistic schedules thereby minimizing the need for management reserve. [PA163.IG101.SP101.SubP102.N101]

   Ensure that estimates of effort required for creating and reviewing of work products (including re-reviews) are made. It is very common during planning to estimate only the effort involved in developing and testing components but not in reviewing them. This is also true for other work products such as documents. Failing to estimate the effort that is required in conducting reviews could force project teams to skip reviews or present unrealistic schedules (since moving a committed date may not be acceptable). [PA163.IG101.SP101.SubP102.N102]

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 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 Project Attributes

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

For Software Engineering

Software 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.AMP101]*

For Software Engineering

Examples of types of work products for which size estimates are made include the following: *[PA163.IG101.SP102.AMP102]*

- *Operational software and support software*
- *Deliverable and non-deliverable work products*
- *Software and non-software work products (e.g., documents)*

For Software Engineering

Examples of size measures include the following: *[PA163.IG101.SP102.AMP103]*

- *Function points*
- *Source lines of code*
- *Number of classes and objects*
- *Number of requirements*
- *Number of pages*

For Systems Engineering

Examples of attributes to estimate include the following: *[PA163.IG101.SP102.AMP104]*

- *Number of functions*
- *Number of inputs and outputs*
- *Data volume*
- *Number and frequency of user interactions*
- *Number of interfaces*
- *Number of technical risk items*
- *Deliverable and non-deliverable work products*

These estimates should be consistent with project requirements to determine the project's effort hours, 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 the attributes increases.
   [PA163.IG101.SP102.SubP102.N102]

   For example, current methods include the following: number of logic gates for integrated circuit design, lines of code or function points for software, number/complexity of requirements for systems engineering, and number of square feet for standard-specified residential homes. [PA163.IG101.SP102.SubP102.N103]

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 from resource and technical approach perspectives. 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 Software Engineering

Examples of software development models include the following: *[PA163.IG101.SP103.N101.AMP103]*

- *Evolutionary*
- *Incremental*
- *Iterative*
- *Spiral*
- *Waterfall*

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 nature of the project. Larger projects may contain multiple phases, such as concept exploration, development, production, operations, and disposal. Within these phases, sub-phases may be needed. A development phase may include sub-phases 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, the timing of the initial planning, as well as the timing and criteria (critical milestones) for replanning. [PA163.IG101.SP103.N103]

Typical Work Products

1. Project life-cycle phases [PA163.IG101.SP103.W101]
2. Product life-cycle phases [PA163.IG101.SP103.W102]

SP 1.4 Determine Estimates of Effort and Cost

Estimate the project effort and cost for the attributes of 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 the size, activities, and other planning parameters. Confidence in these estimates is based on the rationale for selected model and the nature of the data. There may be occasions where the available historical data does not apply, e.g., where efforts are unprecedented and when 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 schedule estimates [PA163.IG101.SP104.W103]
4. 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, schedule, 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 schedule and cost. [PA163.IG101.SP104.SubP102]

The support infrastructure includes items needed from a life-cycle 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: identifying the critical computer resources for the software project
basing estimates of critical computer resources on allocated requirements *[PA163.IG101.SP104.SubP102.N101.AMP101]*

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 the 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
- Work breakdown structure
- 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

4. Confirm that effort and cost estimates are based on credible prediction factors (rationale) that take into account: work product size and complexity, requirements, risk, technical feasibility, security issues, precedence, historical performance, and availability of personnel skill. [PA163.IG101.SP104.SubP104]

   Confirmation of resource estimates can be accomplished with structured reviews that check the adequacy and reasonableness of the estimating rationale. [PA163.IG101.SP104.SubP104.N101]

SG 2 Develop a Project Plan [PA163.IG102]

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

A project plan is a formal, approved document used to manage and control the execution of the project and 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 and planning should ensure that subordinate plans are consistent with each other and 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 ensuring that budget allocation, task complexity, and task dependencies are appropriately addressed. [PA163.IG102.SP101.N101]

Event-driven 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 these 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 based 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
- Using appropriate historical data to verify the schedule
- Defining incremental funding requirements

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 essential to formulate a rigorous and objective standard for determining when a corrective action should be taken. [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 practice should be extended down to all the subordinate plans to ensure that the appropriate interfacing is taking place between all relevant stakeholders on identified risks. Project planning risk identification and analysis typically includes 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 practice 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 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, 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 multi-media). Data may be deliverable (e.g., items identified by a program's contract data requirements) or data may be non-deliverable (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 validation of project deliverables and non-deliverables, contract and non-contract data requirements and customer-supplied data. All too 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 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. Plan for the definition, collection, and analysis of project data. [PA163.IG102.SP102.SubP103]

Refer to the Measurement and Analysis process area for planning for the definition, collection, and analysis of project progress and performance data. [PA163.IG102.SP102.SubP103.R101]

Progress and performance data (e.g., effort, cost, schedule, and technical performance) are essential for project tracking, re-planning, and estimating new tasks. [PA163.IG102.SP102.SubP103.N101]

Refer to the Define Measures specific practice of the Measurement and Analysis process area for examples of project management metrics.
[PA163.IG102.SP102.SubP103.N101.R101]

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 what quantities of each should be used to perform project activities builds on the estimates and provides additional information for the expansion of the WBS for the managing 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. This is the level at which organizational functions are assigned to perform the WBS tasks. This intersection of product and function is typically called a cost account. Each task or work product at this lower-level 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 task dictionary that describes the work for each task 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 is crucial to project success.
   [PA163.IG102.SP104.SubP103.N101]

   Even when the required assets are not unique, comprising 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 one aspect of the scope of an effort that is 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. Inventory of skill needs [PA163.IG102.SP105.W102]
3. New hire plans [PA163.IG102.SP105.W103]
4. 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 or project)
- External training
- 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 with 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 product 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 those to be engaged 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 stakeholders will probably change as the project moves through the product life cycle. It is important however to assure that stakeholders in the later phases of the life cycle have early inputs 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 stakeholders with respect to the project by project life-cycle phase
- Relationships between stakeholders
- Relative importance of the stakeholder to project success by project phase
- Resources (e.g., training, materials, time, funding) needed to ensure stakeholder interaction
- Schedule for phasing of stakeholder interaction

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

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 produced comprising 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 the significant accomplishments with pass/fail criteria for both business and technical elements of the project necessary to complete the work 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 captured in a related Integrated Master Plan.*
- *System 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]*

- *A software development plan*
- *A software project plan*
- *A software plan*

A documented plan that address 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: product 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 [PA163.IG103]

Commitments to the project plan are established and maintained.

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

SP 3.1 Review Subordinate Plans

Review subordinate plans 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 subordinate plans to review.
[PA163.IG103.SP103.AMP101]

Subordinate plans and strategies developed within other process areas will typically contain the same type of information as called out for the overall project plan but tailored to the scope of that particular area. The subordinate plans should be compatible with and support the overall project plan to know who has the authority, responsibility, accountability and control. These subordinate plans should be reviewed to ensure a common understanding of the scope, goals, roles, and relationships that are required for the project to be successful. [PA163.IG103.SP103.N101]

Typical Work Products

1. Record of subordinate plan reviews [PA163.IG103.SP103.W101]

SP 3.2 Reconcile Work and Resource Levels

Reconcile the project plan to reflect available and projected 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 subordinate plans 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. Re-negotiated 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 the 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 assuring 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 assure a consistent mutual understanding as well as for tracking and maintenance. Provisional commitments should be accompanied by a description of the risks associated with this 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, for monitoring. [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]

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the requirements and objectives, and plans for performing the project planning process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are described in the plan for project planning. This plan for project planning differs from the project plan described in the specific practices in this process area. The project plan addresses the specific needs and objectives for the project; whereas the plan for project planning addresses the overall planning of this process area and how the specific practices will be performed. [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 tools used in performing the activities of the Project Planning process area include the following: [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 anlaysis
- Data management
- Planning
- Scheduling

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]

At the project level, consider stakeholders from among 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: [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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Project Planning process area include the following: [PA163.EL113]

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

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the project planning process and the work products and services of the process to the applicable requirements, objectives, and standards, 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]

- Work breakdown structure
- 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]*

PROJECT MONITORING AND CONTROL

Maturity Level 2

Purpose

The purpose of Project Monitoring and Control is to provide understanding into 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 it precludes meeting project objectives if left unresolved. [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 measures, including measuring, analyzing, and recording. [PA162.R102]

Specific and Generic Goals

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

Actual performance and progress of the project is 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.

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 Correction Action
- SP 2.3 Manage Corrective Action

GG 2 Institutionalize a Managed Process

- 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

Specific Practices by Goal

SG 1 Monitor Project Against Plan [PA162.IG101]

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

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]

Refer to the Measurement and Analysis process area for periodically measuring, analyzing, and recording the actual attributes of the work products and tasks and other planning parameters and comparing them to their associated estimates. *[PA162.IG101.SP101.N101.R101]*

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. Analysis of the impact of significant deviations to determine what corrective action 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 documented in the project plan
   - Identifying significant deviations from the estimates 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 of 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, e.g. 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, test and operation
- Networks
- Security environment
- Manpower
- Processes

5. Monitor the knowledge and skills of project personnel.
[PA162.IG101.SP101.SubP105]

Refer to Project Planning process area for information about planning for knowledge and skills needed to perform the project.
[PA162.IG101.SP101.SubP105.R101]

Monitoring of 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 those affected. [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. *[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 are specified in project planning, that involvement must be monitored to ensure that the appropriate interactions are occurring with the appropriate stakeholders. [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 stakeholders affected 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]

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]

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 the 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 stakeholders affected 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 [PA162.IG102]

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

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]

Refer to the Verification and Validation process areas for more information about how discovered issues are handled

[PA162.IG102.SP101.SubP101.R101]

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 Project Planning process area for information about corrective action criteria. *[PA162.IG102.SP101.SubP102.R101]*

Corrective action is required when the issue may prevent the project from meeting its objectives if left unresolved. [PA162.IG102.SP101.SubP102.N101]

SP 2.2 Take Correction 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 appropriate 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 correction action. [PA162.IG102.SP103.SubP102]

3. Determine and document appropriate actions to correct deviations from planned results for corrective actions. [PA162.IG102.SP103.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 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]

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the requirements and objectives, and plans for performing the project monitoring and control process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are typically described in 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 tools used in performing the activities of the Project Monitoring and Control process area include the following: [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: [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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Project Monitoring and Control include the following: [PA162.EL105]

- Number of open and closed corrective actions
- Project milestone dates (e.g., planned versus actual and slipped milestones)

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the project monitoring and control process and the work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA162.EL106]

- Monitoring the project 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]*

SUPPLIER AGREEMENT MANAGEMENT

Maturity Level 2

Purpose

The purpose of Supplier Agreement Management is to manage the acquisition of products and services from suppliers external to the project for which there exists a formal agreement. [PA166]

Introductory Notes

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]

The acquired product may be a product component in the overall product under development. In this process area, “product” will be used to refer to both products and product components acquired from a supplier. [PA166.N102]

The Supplier Agreement Management process area addresses the need of the project to effectively select and manage those portions of work that are produced by suppliers. The term "supplier" is used to identify an internal or external organization that develops, manufactures, or supports products being developed or maintained that will be delivered to the customer. Suppliers may take many forms depending on business needs including in-house vendors (i.e., organizations within a company but which are external to the project), fabrication capabilities and laboratories, and commercial vendors. [PA166.N103]

The Supplier Agreement Management process area involves the following activities: [PA166.N104]

- Identifying the products to be acquired
- Selecting suppliers
- Establishing and maintaining agreements with suppliers
- Overseeing supplier performance
- Accepting delivery of products
- Arranging for maintenance and support of the products

This process area does not directly cover the acquisition of products that are not delivered to the project's customer (for example, development tools). When development tools are not delivered to the customer, a project may choose to use the practices in this process area to minimize the risk to the project. However, if the project establishes an environment that includes development tools and this environment is part of the products that are delivered to the customer, this process area is applicable. [PA166.N105]

This process area also does not directly cover arrangements where the supplier is integrated into the project team (for example, integrated product teams, virtual organizations, or employees from a supplier supplementing the project's staff). Although these situations typically require formal agreements, they are often handled by other functions outside of the project. Again, the practices of this process area may be useful to the project in these situations. [PA166.N106]

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.

Practice to Goal Relationship Table

SG 1 Establish Supplier Agreements [PA166.IG101]
- SP 1.1 Analyze Needs and Requirements Determined by the Project
- SP 1.2 Select Suppliers
- SP 1.3 Establish Supplier Agreements

SG 2 Satisfy Supplier Agreements [PA166.IG102]
- SP 2.1 Acquire COTS Products
- SP 2.2 Execute the Supplier Agreement
- SP 2.3 Conduct Acceptance Testing
- SP 2.4 Transition Products

GG 2 Institutionalize a Managed Process
- 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

Specific Practices by Goal

SG 1 Establish Supplier Agreements [PA166.IG101]

Agreements with the suppliers are established and maintained.

SP 1.1 Analyze Needs and Requirements Determined by the Project

Analyze the project's needs and requirements that will be fulfilled by sources outside the project to determine how the needs and requirements will be satisfied. *[PA166.IG101.SP101]*

For Integrated Product and Process Development

When integrated teams are formed, the risk to the acquirer may be unacceptable if the suppliers for one, or more, of the products needed are not employing IPPD approaches. In analyzing needs,the project should consider whether or not to use a non-IPPD supplier. *[PA166.IG101.SP101.AMP101]*

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 when the requirements are being developed, continues during the design process, and is completed with the decision to acquire the product. [PA166.IG101.SP101.N101]

Refer to the Requirements Development process area for more information about determining the product and product component requirements. *[PA166.IG101.SP101.N101.R101]*

Refer to the Requirements Management process area for more information about managing requirements. *[PA166.IG101.SP101.N101.R102]*

Refer to the Technical Solution process area for more information about design decisions for the make-or-buy analysis. *[PA166.IG101.SP101.N101.R103]*

Factors affecting the make-or-buy decision include the following: [PA166.IG101.SP101.N102]

- 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 commercial-off-the-shelf (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 and are covered by the practices described in the Requirements Development, Technical Solution, and Project Planning process areas. [PA166.IG101.SP101.N105]

The make-or-buy decision can be conducted using a structured decision-making approach [PA166.IG101.SP101.N103]

Refer to the Decision Analysis and Resolution process area for more information about structured decision-making. *[PA166.IG101.SP101.N103.R101]*

Typical Work Products

1. List of products to be acquired [PA166.IG101.SP101.W101]
2. Outsourcing needs and requirements [PA166.IG101.SP101.W102]

Subpractices

1. Select acquisition options for the candidate products to be acquired to satisfy the project's needs and requirements.
   [PA166.IG101.SP101.SubP101]

   These options include the following: [PA166.IG101.SP101.SubP101.N101]

   - Purchasing COTS products or services
   - Obtaining products or services through a contractual agreement
   - Obtaining products or services from another part of the business enterprise (i.e., another part of the corporation, government agency, etc.)
   - 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)

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 decision-making 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: [PA166.IG101.SP102.N103]

- Geographical location of the supplier
- Supplier's performance records on similar work
- Engineering capabilities
- Staff 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]

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

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 needs to be negotiated with suppliers and incorporated into the agreement. The agreement needs to 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]

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, specification, terms and conditions, a list of deliverables, a schedule, 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 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 [PA166.IG102]

Agreements with the suppliers are satisfied by both the project and the supplier.

SP 2.1 Acquire COTS Products

Acquire COTS products to 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]

The identification of product components that will be satisfied by COTS is done in the Technical Solution process area. [PA166.IG102.SP101.N102]

Refer to the Technical Solution process area for more information about the identification of product components that will be satisfied with COTS products. *[PA166.IG102.SP101.N102.R101]*

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]

Subpractices

1. Develop criteria for evaluating COTS products. [PA166.IG102.SP101.SubP101]
2. Evaluate candidate products against the associated requirements and criteria. [PA166.IG102.SP101.SubP102]

Refer to the Requirements Management and the Requirements Development process areas for more information about the requirements that will be used to evaluate candidate products. *[PA166.IG102.SP101.SubP102.R101]*

These requirements include 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 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 products
- Cost and effort to incorporate the 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 and the Risk Management process areas 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 standard 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
- Covering 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 [PA166.IG102.SP102.W101]
2. Results of audit reviews [PA166.IG102.SP102.W102]
3. Review reports [PA166.IG102.SP102.W103]
4. Action items [PA166.IG102.SP102.W104]
5. Documentation of work 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 process activities 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 to closure all action items
- Preparing and distributing to the affected people 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 suppliers technical activities and verifying that the supplier's interpretation and implementation of the requirements are consistent with the project's interpretation, technical commitments are being met, and technical issues are communicated and resolved in a timely manner

- Obtaining technical information about the supplier's work 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 results to improve the supplier's performance and for establishing and nurturing 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 Conduct Acceptance Testing

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 the acceptance of 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 reports [PA166.IG102.SP103.W102]

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. Verify that the non-technical commitments associated with the acquired work product are satisfied. [PA166.IG102.SP103.SubP104]

   This may include verifying 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]*

Typical Work Products

1. Transition plans [PA166.IG102.SP104.W101]
2. Training plans [PA166.IG102.SP104.W102]
3. Support and maintenance plans [PA166.IG102.SP104.W103]

Subpractices

1. Ensure 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 the people involved in receiving, storing, using, and maintaining the acquired products. [PA166.IG102.SP104.SubP102]
3. Ensure that storing, distributing, and using the acquired products is 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 requirements and objectives, and plans 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]*

Elaboration:

Examples of tools used in performing the activities of the Supplier Agreement Management process area include the following: [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 acuired products
- Receiving, storing, using, and maintaining the 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 list

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: [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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Supplier Agreement Management process area 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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]*

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

Measurement 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, 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 project processes 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 people 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 organizational and/or enterprise wide information needs. [PA154.N104]

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 an Organizational 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 practices 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.

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

- 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

Specific Practices by Goal

SG 1 Align Measurement and Analysis Activities [PA154.IG101]

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

The specific practices covered under this specific goal may be addressed concurrently or in differing 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 prematurely 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, or process implementation needs. [PA154.IG101.SP101.N102]

The measurement objectives may also be constrained by existing developmental 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
- 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. Documented 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 revise 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 affected stakeholder groups, and revised 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., pages)
- Estimates and actual measures of effort and cost (e.g., person hours)
- Quality measures (e.g., number of defects, severity of defects)

Examples of commonly used derived measures include the following: [PA154.IG101.SP102.N104]

- Earned Value (e.g. Actual Cost of Work Performed / Budgeted Cost of Work Performed)
- Schedule Performance Index
- Defect Density
- Peer review coverage
- Test or verification coverage
- Reliability measures (e.g., mean time to failure)

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. Documented 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 term. 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 revise measures. [PA154.IG101.SP102.SubP104]

   Proposed specifications of the measures are reviewed for their appropriateness with potential end users and other stakeholders. Priorities are set or changed, and specifications of the measures are revised 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. Documented 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 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: [PA154.IG101.SP103.SubP105.N102]

- Time stamped 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 revise 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 suggest other useful measures or analyses. [PA154.IG101.SP103.SubP106.N101]

7. Revise 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. Documented 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 is paid to the analyses that will be conducted and to the manner in which the results will be reported as follows. [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 Quantitative Project Management process area, Specific Practices 4 & 5 for more information about understanding variation and the appropriate use of statistical analysis techniques.

[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

Descriptive statistics should typically do the following: [PA154.IG101.SP104.SubP102.N102]

- Examine distributions on the specified measures (e.g., central tendency, extent of variation, presence of atypical outliers)
- Examine the interrelationships among those measures (e.g., comparisons of defects by life-cycle status or 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 revise the content and format of the proposed 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 stakeholders consulted should include intended end users, sponsors, data analyst, and data providers. [PA154.IG101.SP104.SubP104.N101]

5. Revise 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 include 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 are 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 [PA154.IG102]

Measurement results that address identified information needs and objectives are provided.

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 judgement (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 affected parties, 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 rarely "speak for themselves." 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 affected 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]

   Affected 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 typically stored 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]

When data are shared more widely across projects, the data may reside in an organizational measurement repository. [PA154.IG102.SP103.N106]

Refer to the Organizational Process Definition process area, Specific Goal 2, Specific Practice 2 for more information about establishing an Organizational 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 may 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 rank projects
> - Impugning the integrity of specific individuals.

SP 2.4 Communicate Results

Report results of measurement and analysis activities to all affected stakeholders. *[PA154.IG102.SP104]*

The results of the measurement and analysis process are communicated to stakeholders in a timely and usable fashion to support decision making and assist in taking corrective action. [PA154.IG102.SP104.N101]

Affected 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. Transmittal and guidance documents [PA154.IG102.SP104.W102]

Subpractices

1. Keep 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]

2. Assist measurement 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 stakeholders. They are understandable, easily interpretable, and clearly tied to identified information needs and objectives. [PA154.IG102.SP104.SubP102.N101]

The data often do not "speak for themselves" 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 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 practices with identified information needs and objectives and for providing measurement results. [PA154.EL101]

Ability to Perform

GP 2.2 (AB 1) Plan the Process

Establish and maintain the requirements and objectives, and plans 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]*

Elaboration:

Measurement personnel may be employed full-or part-time. A measurement group may or may not exist to support measurement activities across multiple projects. [PA154.EL104]

Examples of tools used in performing the activities of the Measurement and Analysis process area include the following: [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-realted measurements (e.g., GQM)

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

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: [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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Measurement and Analysis process area include the following: [PA154.EL111]

- Percentage of project using progress and performance measures
- Percentage of measurement objectives addressed

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the measurement and analysis process and the work products and services of the process to the applicable requirements, objectives, and standards, 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]*

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 the processes and associated work products. [PA145]

Introductory Notes

Process and Product Quality Assurance involves the following: [PA145.N101]

- Objectively evaluating performed process, 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 the quality assurance activities
- Ensuring that noncompliance issues 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 cycle. [PA145.N102]

Process and Product Quality Assurance ensures planned processes are implemented while Verification ensures that the specified requirements are satisfied. Process and Product Quality Assurance and Verification may on occasion look at the same 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. 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 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 the Process and Product Quality Assurance function is embedded in the process, a number of issues need to 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 products. An independent reporting channel to the appropriate level of organizational management allows noncompliance issues to be escalated as necessary. [PA145.N105]

Process and Product Quality Assurance should begin in the early stages 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 the quality assurance function participate in establishing the plans, processes, standards and procedures to ensure 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 life cycle 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 can not 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 projects and services, but it also applies to evaluations of non-project 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 the quality assurance function will objectively evaluate. *[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.

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

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

Specific Practices by Goal

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.

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 Process and Product Quality Assurance evaluations is critical to the success of the project. A description of the quality assurance reporting chain and how it ensures objectivity of the process and product quality assurance function needs to be defined to ensure objectivity. [PA145.IG101.SP101.N101]

Typical Work Products

1. Audit reports [PA145.IG101.SP101.W101]
2. Noncompliance reports [PA145.IG101.SP101.W102]
3. Corrective actions [PA145.IG101.SP101.W103]

Subpractices

1. Advance use of 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 during the evaluation process
   - 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]

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. Audit 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 delivery 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 noncompliance found during the evaluations. [PA145.IG101.SP102.SubP107]

8. Identify lessons learned that improve processes for future products and services. [PA145.IG101.SP102.SubP108]

SG 2 Provide Objective Insight [PA145.IG102]

Noncompliance issues are objectively tracked and communicated, and resolution is ensured.

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. Audit 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 are not able to 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. Audit logs [PA145.IG102.SP102.W101]
2. Quality assurance reports [PA145.IG102.SP102.W102]
3. Status of corrective actions [PA145.IG102.SP102.W103]
4. 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 that processes and associated work products adhere to the applicable process descriptions, standards, and procedures, and ensuring that noncompliance are addressed. [PA145.EL101]

This policy also establishes the expectation that the process and product quality assurance function is in place for all projects and possesses 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 requirements and objectives, and plans 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]*

Elaboration:

Examples of tools used in performing the activities of the Process and Product Quality Assurance process area include the following: [PA145.EL105]

- Auditing 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 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]*

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

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
- Audit 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: [PA145.EL113]

- Establishing criteria for the objective evaluations of processes and work products
- Evaluating processes and work products
- Resolving issues on noncompliances
- 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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Process and Product Quality Assurance process area include the following: [PA145.EL108]

- Variance of objective process evaluations planned and performed
- Variance of objective 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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
- Audit 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]*

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

Configuration Management 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. [PA159.N102]

Examples of work products that may be placed under configuration management include: [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. A "configuration item" is an entity designated for configuration management, which may consist of multiple related work products. 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]

A "baseline" describes one or more configuration items and the associated entities of which it is composed. Baselines provide a stable basis for continuing evolution of configuration items. [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]

A configuration management system is established containing the baselines 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 includes control of content, versions, changes, and distribution of data. It is focused on the rigorous control of the managerial and technical aspects of the 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 - a method of dividing project work that 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 and maintained.

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.

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 Changes
- SP 2.2 Control Changes

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
- 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

Specific Practices by Goal

SG 1 Establish Baselines [PA159.IG101]

Baselines of identified work products are established and maintained.

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 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. 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.N101]

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 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 and a change in one mandates a change in 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 the point in its development that 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 development 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 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 to satisfy necessary privacy and security requirements for the configuration items

Three examples of configuration management systems are as follows: [PA159.IG101.SP102.SubP101.N102]

- Dynamic (or developer's) systems contain components currently being created or revised. They are 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.

2. Store and retrieve configuration items in the configuration management system. [PA159.IG101.SP102.SubP102]

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 constitutes approval of a set of configuration data for the agreed upon set of configuration items from the configuration management system and releasing it 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, allocated, and product baselines. *[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 an external 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

   Assure 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 [PA159.IG102]

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

SP 2.1 Track Changes

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]

Changes 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 system. [PA159.IG102.SP101.SubP101]

2. Analyze the impact of proposed changes and fixes. [PA159.IG102.SP101.SubP102]

   Changes are evaluated through a process that ensures they are consistent with all the technical and project requirements. [PA159.IG102.SP101.SubP102.N101]

   Changes are evaluated for their impact beyond the 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 and get agreement with those affected by change requests that will be addressed in the next baseline. [PA159.IG102.SP101.SubP103]

   Schedule and conduct the change-request review by appropriate participants in the decision. Record the disposition and rationale, 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 affected parties. [PA159.IG102.SP101.SubP103.N101]

4. Track the status of change requests to closure. [PA159.IG102.SP101.SubP104]

   Changes 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 Changes

Control changes to the content of 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 baseline [PA159.IG102.SP102.W102]

Subpractices

1. Control changes to configuration items throughout the life cycle.
   [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, an authorization may come from CCB, 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]

   - Verifying 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 safety and/or security of the system.
   [PA159.IG102.SP102.SubP104]
5. Record changes 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 process could be shorter 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 [PA159.IG103]

Integrity of baselines is established and maintained.

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 changes [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 affected individuals and groups 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. Verify 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. Verify 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. Verify 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 of identified work products, 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 requirements and objectives, and plans 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]*

Elaboration:

Examples of tools used in performing the activities of the Configuration Management process area include the following: [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
- Configuration Control Board meeting minutes
- Archived baseline

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: [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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Configuration Management process area include the following: [PA159.EL108]

- Number of changes to configuration items
- Number of configuration audits conducted

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the configuration management process and the work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA159.EL109]

- Establishing and maintaining baselines
- Tracking and controlling changes
- Establishing and maintaining integrity of baselines

Examples of work products reviewed include the following: [PA159.EL110]

- Archives 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]*

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 (IPPD)
- Risk Management
- Integrated Teaming
- Decision Analysis and Resolution
- Organizational Environment for Integration

Refer to the Model Components section of the Structure of the Model chapter of the Overview for more information about CMMI maturity levels. *[FM110.T101.R101]*

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

The Requirements Development process area includes three principal groups of practices. The first includes those required to define a complete set of customer requirements to use in the development of product requirements. The second includes those required to define a complete set of product and product component requirements to use in the design of the products and product components. The third includes those for performing the necessary analysis to define, derive and understand the requirements. The three groups of practices may interact recursively with each other and the definition of alternative solutions and preferred product concepts developed in the Technical Solution process area. [PA157.N101]

Requirements are developed that will be the basis for design. This includes the following: [PA157.N102]

- 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
- Elicitation, analysis, and communication of customer needs, expectations, and constraints to obtain customer requirements that constitute an understanding of what will satisfy stakeholders

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 solution. [PA157.N104]

Requirements evolve throughout the product life cycle. Design decisions, subsequent corrective actions, and feedback from production, integration, verification, validation, product operations, support, and disposal are analyzed for impact on derived and allocated requirements. [PA157.N105]

Analyses are used to understand, define, and select the requirements at all levels from competing alternatives. Analysis includes the following: [PA157.N106]

- Analysis of needs and requirements
- Development of an operational concept
- Definition of the required functionality
- Development of manufacturing and support concepts to address cost and affordability

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 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) and the manufacturing or production concept produces more derived requirements including consideration of the following 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 all 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 process area 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.

6890 **SG 2** **Develop Product Requirements** [PA157.IG103]

6891 ***Customer requirements are refined and elaborated to develop product and***
6892 ***product component requirements for the product life cycle.***

6893 **SG 3** **Analyze and Validate Requirements** [PA157.IG102]

6894 ***The requirements are analyzed and validated, and a definition of required***
6895 ***functionality is developed.***

6896 **GG 3** **Institutionalize a Defined Process** [CL104.GL101]

6897 ***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 Transform Stakeholder Needs, Expectations, Constraints, and Interfaces into 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 Evaluate Product Cost, Schedule and Risk
- SP 3.5 Validate Requirements with Comprehensive Methods

GG 3 Institutionalize a Defined Process
- 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 [PA157.IG101]

Stakeholder needs, expectations, constraints, and interfaces are collected and translated into customer requirements.

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. Stakeholder needs, expectations, constraints, and limitations must be clearly identified and understood. An iterative process is used throughout the life of the project to accomplish this objective. In the case of non-negotiated situations, the surrogate for the end-user or customer is frequently 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. Environmental, legal, and other constraints that may be external to the customer must also be applied 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's life cycle. *[PA157.IG101.SP102]*

Eliciting goes beyond collecting requirements to proactively identify additional requirements not explicitly provided by customers. They should address the various 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
- Prototypes and models
- Brainstorming
- Quality function development
- 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 (e.g., dialogue, scenario reviews, models, simulations, prototypes, or new technology demonstrations). [PA157.IG101.SP102.SubP101]

2. Remove conflicts in stakeholder needs, expectations, constraints, and interfaces and organize into related subjects based on analysis. [PA157.IG101.SP102.SubP102]

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 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's 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 may or may not be in stated technical terms. They should address the various life-cycle activities and their impact on the product. [PA157.IG101.SP101.N101]

Subpractices

1. The basic activity addresses the receipt of requirements that a customer provides to define what is needed or desired. These may or may not be in technical terms. They should address the various life-cycle activities and their impact on the product.

   [PA157.IG101.SP101.SubP101]

   Inputs include needs, expectations, constraints and external interfaces.

   [PA157.IG101.SP101.SubP101.N101]

SP 1.2 Transform Stakeholder Needs, Expectations, Constraints, and Interfaces into Customer Requirements

Transform stakeholder needs, expectations, constraints, and interfaces into customer requirements. *[PA157.IG101.SP103]*

For Integrated Product and Process Development

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. Customers 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 need to be consolidated, missing information obtained, conflicts resolved and documented as 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. Requirements for verification process [PA157.IG101.SP103.W102]
3. Requirements for validation process [PA157.IG101.SP103.W103]
4. Test cases and expected results [PA157.IG101.SP103.W104]

Subpractices

1. Translate the stakeholder needs, expectations, constraints, and interfaces into documented customer requirements. [PA157.IG101.SP103.SubP101]
2. Define methods, criteria, and constraints for the verification and validation processes. [PA157.IG101.SP103.SubP102]

SG 2 Develop Product Requirements [PA157.IG103]

Customer requirements are refined and elaborated to develop product and product component requirements for the product life cycle.

Customer requirements are analyzed in conjunction with the development of the operational concept to derive a more detailed and precise sets of requirements called "product and product component requirements." 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 re-examined 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 captured. 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]

SP 2.1 Establish Product and Product Component Requirements

Establish and maintain, from the customer requirements, product and product component requirements essential to product and product component effectiveness and affordability. *[PA157.IG103.SP101]*

The customer requirements may be expressed in the customer's terms and may be non-technical 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, resonant frequencies, etc. [PA157.IG103.SP101.N101]

Design constraints include specifications on product components that derive 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]

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]
4. House of quality [PA157.IG103.SP101.W104]

Subpractices

1. Develop requirements in technical terms necessary for product and product component design. [PA157.IG103.SP101.SubP101]
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 additional requirements. For instance, use of electronics necessitates 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 practice provides information for defining the allocation of requirements but must interact with the 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 between derived requirements [PA157.IG103.SP102.W105]
6. Specifications [PA157.IG103.SP102.W106]

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 between allocated requirements. [PA157.IG103.SP102.SubP104]

   Relationships include dependencies such that 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 defined. Functional interfaces may drive the development of alternative solutions 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 architecture and design are defined. They are controlled as part of product and product component integration. [PA157.IG103.SP103.N102]

Life-cycle process interfaces must also be identified. [PA157.IG103.SP103.N103]

Examples of these interfaces include interfaces with test equipment, transportation systems, support systems, and manufacturing facilities. [PA157.IG103.SP103.N104]

Typical Work Products

1. Interface requirements [PA157.IG103.SP103.W101]

Subpractices

1. Identify interface requirements both external to the product and internal to the product (i.e., between functional partitions or objects). [PA157.IG103.SP103.SubP101]

2. Fully define interfaces in terms of origination, destination, stimulus, and data characteristics for software, electrical, and mechanical characteristics for hardware. [PA157.IG103.SP103.SubP102]

Refer to the Technical Solution process area for information about generating interface requirements during the design process. As architectures are determined and interfaces are created, new interfaces are created. Also, as interface designs are defined, the design becomes a requirement for products and product components that are affected by the interface *[PA157.IG103.SP103.SubP102.R101]*

For internal interfaces, this information may be created as part of the design process. [PA157.IG103.SP103.SubP102.N101]

SG 3 Analyze and Validate Requirements [PA157.IG102]

The requirements are analyzed and validated, and a definition of required functionality is developed.

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 time line 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 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 scenarios.

[PA157.IG102.SP101]

Refer to the Technical Solution process area for detailed development of operations 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 that 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 define the interaction of the product, the end-user, and the environment, 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 association with requirements is referred to as a functional architecture. [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 derived requirements to ensure that they are necessary and sufficient. *[PA157.IG102.SP103]*

The derived requirements are analyzed in light of the operational concept and scenarios to support the development of a more detailed and precise set of product or product component requirements. The analysis makes sure that the derived requirements are necessary and sufficient to meet the objectives of higher level requirements. [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 key actions is the determination of which requirements will be identified to track technical progress against. 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 derived 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 the understanding of which requirements impact 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 on the general use of measurements. *[PA157.IG102.SP103.SubP105.R101]*
6. Analyze operational concepts and scenarios to refine the customer needs, constraints and interfaces and 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 Evaluate Product Cost, Schedule and Risk

Analyze requirements with the purpose of reducing the life-cycle cost, schedule and risk of product development. *[PA157.IG102.SP104]*

Use validated models, simulations, and prototyping to analyze the cost and risk associated with the customer requirements. Results of the analyses can be used to reduce the cost of the product and the risk in developing the product. [PA157.IG102.SP104.N101]

Typical Work Products

1. Assessment of risks related to requirements [PA157.IG102.SP104.W101]

Subpractices

1. 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]*

2. Examine 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 the 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 showing the customers and end users prototypes, simulations, analyses, scenarios, and storyboards. [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 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]*

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 the risk management activities.

[PA157.IG102.SP105.N101]

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 requirements and objectives, and plans for performing the requirements development process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are typically described in 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 tools used to perform the activities of the Requirements Development process area include the following: [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

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]*

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:

For engineering processes, consider stakeholders among 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: [PA157.EL114]

- Reviewing adequacy of requirements to meet 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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Requirements Development process area 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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

7491 **GP 2.10 (VE 2) Review Status with Higher-Level Management**

7492 ***Review the activities, status, and results of the requirements***
7493 ***development process with higher-level management and resolve***
7494 ***issues.*** *[GP112]*

TECHNICAL SOLUTION

Maturity Level 3

Purpose

The purpose of Technical Solution is to develop, design, and implement solutions to requirements. Solutions, designs and implementations encompass products, product components, and product related 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, 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

In practice, these activities interactively support with 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 complete technical data package or a complete set of requirements. [PA160.N102]

Technical Solution practices apply not only to the product and product components but also to services and product-related processes. The product-related processes are developed in concert with product, or product component, development. Such development may include selecting and adapting existing processes (including standard processes) for use as well as developing new processes. [PA160.N103]

Requirements for the product that originate in the Requirements Development process area or elsewhere are received from the Requirements Management process area after they have been placed under appropriate configuration management and after the traceability to previous requirements has been accomplished. [PA160.N104]

For a 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 life cycle utilization or other aspects of the operating environment for which modifications may be necessary (e.g., changes in stress spectrum resulting in unplanned for and accelerated mechanical aging or changes in the operating system software). Such occurrences are uncovered during continuous verification of the product(s) as used in their operating environment. These verifications expose actual performance delivered which can be compared against the performance specified and unacceptable degradation identified. The Technical Solution practices should be used to perform the sustainment design efforts. [PA160.N105]

Related Process Areas

Refer to the Requirements Development process area for more information about requirements allocations, establishing operational concept, and interface requirements definition. Technical solutions are developed interactively with requirements definition and both evolve with requirements and stimulate requirements to be refined as the technical solution matures. *[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. As verification issues are identified, the design may need to change. *[PA160.R102]*

Refer to the Decision Analysis and Resolution process area for more information about structured decision making. Selecting the solution from a set of design alternatives is one place the structured Decision Analysis and Resolution process area should be used. *[PA160.R103]*

Refer to the Requirements Management process area for more information about managing requirements. The practices in Requirements Management should be executed concurrently with Technical Solution. *[PA160.R104]*

Refer to the Organizational Innovation and Deployment process area for more information about the organization's technology processes. *[PA160.R105]*

Specific and Generic Goals

SG 1 Select Product Component Solutions [PA160.IG101]

Product or product component solutions, including applicable product related processes, 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 Use Effective Design Methods
- SP 2.2 Establish a Complete Technical Data Package
- SP 2.3 Design Comprehensive Interface
- 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 Establish Product Support Documentation

GG 3 Institutionalize a Defined Process
- 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 [PA160.IG101]

Product or product component solutions, including applicable product related processes, are selected from alternative solutions.

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 solutions 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 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 components. Such is the case at the bottom of the product architecture. There are also cases where one or more of the solutions is fixed (e.g., a specific solution is directed or available products 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 are established together. 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 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]

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 structured decisions. *[PA160.IG101.SP102.R101]*

For Integrated Product and Process Development

The practice of selecting alternative solutions and issues to be subject to decision analyses and trade studies is accomplished by the involvement of relevant stakeholders, representing both business and technical functions and the concurrent development of the life cycle processes (e.g., manufacturing, support, training, verification and disposal) with the product In this way, important issues surface earlier in the product development than with traditional practices and can be addresssed before they become costly mistakes.
[PA160.IG101.SP102.AMP101]

Detailed alternative solutions are an essential concept of Technical Solution. They provide more accurate and comprehensive information about the solution than non-detailed 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 life cycle balanced solution in terms of cost, schedule, and technical performance. 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., executability, technical, cost, schedule). Detailed alternative solutions and selection criteria include the following: [PA160.IG101.SP102.N102]

- Cost (development, procurement/reprocurement, support, life cycle)
- Technical performance
- Complexity of the product component and related life cycle processes
- Robustness to product operating and use conditions, operating modes, environments, and variations in related life-cycle processes
- Product expansion and growth
- Technology limitations
- Sensitivity to construction methods and materials
- Risk
- Evolution of requirements and technology
- Disposal

The considerations listed above are a basic set; organizations should develop a list of screening criteria for alternatives that are consistent with business objectives. 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 should provide a balanced approach to costs, benefits, and risks. [PA160.IG101.SP102.N103]

Typical Work Products

1. Alternative solutions [PA160.IG101.SP102.W101]

2. Selection criteria [PA160.IG101.SP102.W102]

3. Checklists for alternative solution screening criteria [PA160.IG101.SP102.W103]

4. Evaluations of new technologies [PA160.IG101.SP102.W104]

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 the organization's technology processes. *[PA160.IG101.SP102.SubP102.R101]*

The project should identify technologies applied to current products and processes and monitor the progress of currently used technologies through their life cycle. 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. Establish the criteria for selecting the best alternative solution. [PA160.IG101.SP102.SubP105]

Criteria should be included addressing life cycle design issues such as provisions for more easily inserting new technologies or ability to better exploit commercial products. Examples would 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 only as informative material.

SP 1.1-1 Develop Alternative Solutions and Selection Criteria

Develop alternative solutions and establish 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 practices used to determine the need for establishing when alternatives may not be useful. *[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 frequently span a design space that explores the feasible solutions available. 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 established criteria are identified. The selection criteria identify the key factors that provide a basis for the selection of the solution. These criteria should provide meaningful discrimination and an indication of success or goodness in arriving at a life cycle balanced solution. They typically include measures of cost, schedule, performance, and risk. 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. Practices such as those in the Requirements Development process area would then be employed to provide a more complete and robust provisional allocation of requirements to the alternative solutions. 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 be “not 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.N101]

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 develop program as well as the life cycle of the product. 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 in 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 payoff.

[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 actions could range from characterizing the issues as a risk for risk management, adjusting the solution alternative to preclude the issue, rejecting the solution alternative and replacing it with a different alternative.

[PA160.IG101.SP101.SubP104.N101]

5. Obtain a complete requirements allocation for each alternative.

[PA160.IG101.SP101.SubP105]

6. Establish 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 document the stimulus-response time sequenced behavior of the interaction of the product components with the environment, users, and other components. They should be documented for operations, product deployment/delivery, support (including maintenance and sustainment), training, and disposal and for all modes and states. The environments (operating, support, training, etc.) also need to be evolved. The environment experienced by any given product component will be influenced by other product components as well as the external environment. The environments may include thermal, stress, and electromagnetic and other elements that need to be documented. [PA160.IG101.SP103.N101]

Typical Work Products

1. Product component operational concepts, scenarios, and environments for all pertinent life-cycle processes (operations, support, training, manufacturing, verification, deployment/fielding/delivery/disposal) [PA160.IG101.SP103.W101]
2. Timeline analyses of product component interactions [PA160.IG101.SP103.W102]
3. Event trace diagrams [PA160.IG101.SP103.W103]
4. Use cases [PA160.IG101.SP103.W104]

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 between product components. *[PA160.IG101.SP104.R101]*

Refer to the Decision Analysis and Resolution process area for more information about structured decision making. *[PA160.IG101.SP104.R102]*

Selection of the product components that best satisfies the criteria establishes the requirement allocations to product components. The selected alternative is either evolved as lower-level requirements or used to develop the technical data package. The product component to product component interface requirements will be described predominately functionally. Physical interface descriptions will be included in the technical data package when the interface is to items/activities external to the product. [PA160.IG101.SP104.N101]

The description of the solutions and the rationale for selection are documented in an initial technical data package. The technical data package evolves throughout development as solutions and detailed designs are developed and those designs 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. Initial product component technical data package. [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 to be the set of allocated requirements to those product components. [PA160.IG101.SP104.SubP105]
6. Establish and maintain the documentation of the solutions, evaluations, and rationale. [PA160.IG101.SP104.SubP106]

SG 2 Develop the Design [PA160.IG102]

Product or product component designs are developed.

Product or product component designs must provide the appropriate life-cycle content not just for implementation, but also for 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 downstream in 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) 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 life cycle processes, e.g., the manufacturing process and the support process, concurrently with the design of the product unless these processes are selected and not modified from the organization's set of standard processes. *[PA160.IG102.AMP101]*

SP 2.1 Use Effective Design Methods

Establish and use effective design methods. *[PA160.IG102.SP101]*

For Software Engineering

Use effective methods to design software. Examples of techniques and methods that facilitate effective software design include the following: *[PA160.IG102.SP101.AMP101]*

- *Prototypes*
- *Structural models*
- *Object-oriented design*
- *Essential systems analysis*
- *Entity relationship models*
- *Design reuse*
- *Design patterns*

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. For example, software design tools are not particularly effective methods to use when designing hydraulic pumps. Two companies may have very effective design methods for products they specialize in 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 used of the methods. [PA160.IG102.SP101.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 multi-year prototyping effort may not be appropriate for a pump or a software module but might be the right thing to do for an unprecedented, expensive, and complex product development. Rapid prototyping techniques (for example, stereo lithography for the pump), however, may be highly effective for product components of that product. 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.N102]

Typical Work Products

1. Criteria for design methods [PA160.IG102.SP101.W101]
2. Design methods [PA160.IG102.SP101.W102]
3. Criteria for selection of the design method [PA160.IG102.SP101.W103]
4. Design tools [PA160.IG102.SP101.W104]
5. Design processes/activities [PA160.IG102.SP101.W105]

Subpractices

1. Establish and maintain criteria against which the effectiveness of design methods can be determined. [PA160.IG102.SP101.SubP101]
2. Identify, develop, or acquire the design methods that satisfy the criteria. [PA160.IG102.SP101.SubP102]
3. Ensure that the design methods adhere 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)

Examples of attributes for which design criteria can be established may include the following: [PA160.IG102.SP101.SubP103.N102]

- Modularity
- Clarity
- Simplicity
- Maintainability
- Verifiability
- Portability
- Reliability
- Accuracy
- Security
- Performance
- Scalability
- Usability

4. Establish the design methods and their applicability to various aspects of product component design. [PA160.IG102.SP101.SubP104]

For example, this may include a mechanism for determining whether prototyping or other techniques are appropriate parts of the design process.
[PA160.IG102.SP101.SubP104.N101]

5. Use the design method(s) that have been established as effective for the applicable portions of the design. [PA160.IG102.SP101.SubP105]

SP 2.2 Establish a Complete Technical Data Package

Establish and maintain a complete technical data package.
[PA160.IG102.SP103]

A complete technical data package provides the developer with a comprehensive description of the product or product component as it is develops. 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]

A complete technical data package would provide the following if such information is appropriate to the type of product and product component (for example, material or manufacturing requirements may not be useful for software only, service, or process product components): [PA160.IG102.SP103.N103]

- product component descriptions in terms of required life-cycle functionality and performance
- product-related 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/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 cycle
- rationale for decisions and characteristics (requirements, requirement allocations; 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. A particularly useful approach is to choose a taxonomy in which the top level consists of design views such as the following: [PA160.IG102.SP103.N104]

- customers
- the environment
- functionality
- data
- states/modes
- construction

- management

These views are captured in the complete technical data package. [PA160.IG102.SP103.N105]

Typical Work Products

1. Complete 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 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 designs 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. Capture 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 design as necessary. [PA160.IG102.SP103.SubP105]

The following specific practice appears in the continuous representation as SP 2.2-1, but is subsumed in the staged representation by SP 2.2 Establish a Complete Technical Data Package . The specific practice is presented here only as informative material.

SP 2.2-1 Develop a Technical Data Package

Develop a product or product component technical data package.

[PA160.IG102.SP102]

The technical data package provides the description of a product or product component (including product-related processes if not handled as separate product components) that supports an acquisition strategy, or the implementation, production, engineering, and logistics support portions 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, 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.SP102.N101]

Typical Work Products

1. Technical data package [PA160.IG102.SP102.W101]

SP 2.3 Design Comprehensive Interface

Design 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 specifications [PA160.IG102.SP105.W101]
2. Interface control documents [PA160.IG102.SP105.W102]
3. Interface specification criteria and templates [PA160.IG102.SP105.W103]
4. Updates to interface specification templates [PA160.IG102.SP105.W104]

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 Compre-

hensive Interface . The specific practice is presented here 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 documents: [PA160.IG102.SP104.N101]

- product component-to-product component
- lower-level component-to-higher level component
- product component-to-product related process (infrastructure/existing, reused, or developed)
- product component-to-external item interfaces

Typical Work Products

1. Interface design [PA160.IG102.SP104.W101]
2. Interface design documents [PA160.IG102.SP104.W102]

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]*

Refer to the Decision Analysis and Resolution process area for more information about defining criteria, alternatives and performing structured decision making. Make, buy, and reuse decisions significantly impact both project and organization success. *[PA160.IG102.SP106.R101]*

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.R102]*

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 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 suppler 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, engines, etc, are not truly "on-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, inclusion of the requirements, and acceptance criteria, may need to be 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]

Typical Work Products

1. Criteria for design and component reuse [PA160.IG102.SP106.W101]
2. Make or buy analyses [PA160.IG102.SP106.W102]
3. Guidelines for choosing COTS components [PA160.IG102.SP106.W103]

Subpractices

1. 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 [PA160.IG103]

Product components, and associated support documentation, are implemented from their designs.

Product components are implemented from the designs established by the practices in Goal 2. 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]

Examples characteristics of this implementation are: [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 (hardware and software and their integrated product components that are part of the process are built, coded, and integrated as appropriate).
- 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 the following:
[PA160.IG103.SP101.SubP101.AMP102]

- *Casting*
- *Molding*
- *Forming*
- *Joining*
- *Machining*
- *Tooling*
- *Welding*
- *Extruding*

Methods to implement the product components are documented, either directly or by reference, in the project's defined process. [PA160.IG103.SP101.SubP101.N101]

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]

- *Languages standards*
- *Naming conventions for variables*
- *Acceptable language structures*
- *Structure and hierarchy of software 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 standardsinclude the following:
[PA160.IG103.SP101.SubP102.AMP103]

- *Standard Parts Lists*
- *Standard drawing requirements*
- *International Organtization for Standardization (ISO) T3303 standards for manufactured parts*

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]

For Software Engineering

Examples of unit testing methods include the following:
[PA160.IG103.SP101.SubP104.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 the design changes. [PA160.IG103.SP101.SubP105.N101]

SP 3.2 Establish Product Support Documentation

Establish and maintain the end-use documentation. *[PA160.IG103.SP102]*

This 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. 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. On-line help [PA160.IG103.SP102.W105]

Subpractices

1. Review the requirements, the design, the product, and the 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]

   Documentation methods are documented, either directly or by reference, in the project's defined process. [PA160.IG103.SP102.SubP102.N101]

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 designated style manual
   - Use of abbreviations
   - Security classification markings
   - Internationalization requirements

4. Develop preliminary versions of the installation, operation, and maintenance documentation early in the 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:

[PA160.IG103.SP102.SubP106.N101]

- requirements change
- design changes
- product changes
- documentation errors
- work-around fixes

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 requirements and objectives, and plans for performing the technical solution process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are typically described in 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 tools used to perform the activities of the Technical Solution process area include the following: [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)

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]*

Elaboration:

Examples of work products placed under configuration management include the following: [PA160.EL106]

- Product, product component, process, service and interface designs
- Complete technical data package
- Interface design documents
- Criteria for design and component reuse
- Implemented design (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:

For engineering processes, consider stakeholders among 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: [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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Technical Solution process area 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]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the technical solution process and the work products and services of the process to the applicable requirements, objectives, and standards, 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 design (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 though progressive assembly of product components, in one stage or in incremental stages, according to a defined integration strategy. [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 structured approach for selecting the appropriate integration strategy 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 on 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]

The strategy for conducting product integration is established and maintained.

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 Establish a Product Integration Strategy
- SP 1.2 Establish the Product Integration Environment
- SP 1.3 Define Detailed Product Integration Procedures

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 Checkout Assembled Product Components
- SP 3.4 Package and Deliver the Product or Product Component

GG 3 Institutionalize a Defined Process

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 [PA147.IG101]

The strategy for conducting product integration is established and maintained.

Preparing for integration of product components involves establishing and maintaining an integration strategy. An integration strategy is developed early in the project concurrently with the practices in the Technical Solution process area. The integration strategy and supporting documentation identify a sequence for receipt, assembly, and evaluation of the various product components that make up the product. [PA147.IG101.N101]

SP 1.1 Establish a Product Integration Strategy

Establish and maintain a strategy for integration of the product components. *[PA147.IG101.SP101]*

Refer to the Define Interfaces specific practice in the Technical Solution process area for more information about defining interfaces for products and product components. *[PA147.IG101.SP101.R101]*

For Integrated Product and Process Development

The integration strategy should be developed concurrently and iteratively with the product and product component designs. *[PA147.IG101.SP101.AMP101]*

The basis for effective product integration is an integration strategy. A successful integration strategy should use a combination of techniques, depending on the complexity of both the product components to be assembled and the complexity of interim and final assembled products. [PA147.IG101.SP101.N101]

To develop an integration strategy, one must analyze alternative assembly sequences; select the best solution, and identify the environment and a minimum set of procedures for integration of the product components. Availability of the product components, test equipment, procedures, integration environment, and personnel skills are factors in developing the integration strategy. [PA147.IG101.SP101.N102]

Integration strategies 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. For complex products, the integration strategy should be incremental and address the iterative process of build-evaluate-build. [PA147.IG101.SP101.N103]

The integration strategy 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 structured approach to selecting the appropriate product integration strategy. *[PA147.IG101.SP101.N104.R101]*

Refer to the Configuration Management process area for more information about protecting and distributing changes to the product integration strategy so that everyone can know the current state of the interfaces. *[PA147.IG101.SP101.N104.R102]*

Refer to the Risk Management process area for more information about identifying and handling risks in the product integration strategy.
[PA147.IG101.SP101.N104.R103]

Typical Work Products

1. Product integration sequence and the rationale for selecting it [PA147.IG101.SP101.W101]
2. Rationale for rejecting other assembly scenarios [PA147.IG101.SP101.W102]
3. Product Integration environment definition [PA147.IG101.SP101.W103] Error - No case for: Comment
4. Product integration procedures and criteria [PA147.IG101.SP101.W104]
5. Evaluation strategy for assemblies of product components [PA147.IG101.SP101.W105]
6. Product integration strategy documentation [PA147.IG101.SP101.W106]

Subpractices

1. Identify the product components to be assembled. [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 the product integration environment required for integrating the product components. [PA147.IG101.SP101.SubP103]

   This can include defining the specific tools and test equipment to establish the product integration environment. [PA147.IG101.SP101.SubP103.N101]
4. Identify the logical sequences for integrating the product components. [PA147.IG101.SP101.SubP104]
5. Develop the product integration strategy. [PA147.IG101.SP101.SubP105]

Example contents of the product integration strategy include the following: [PA147.IG101.SP101.SubP105.N101]

- The product integration sequence
- The work to be done
- The responsibilities for each activity and the resources required
- The schedule to be met
- The procedures to be followed
- The tooling required

6. Periodically review the product integration strategy and revise as needed. [PA147.IG101.SP101.SubP106]

   Assess the integration strategy 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]

7. Capture the rationale for decisions taken and deferred. [PA147.IG101.SP101.SubP107]

8. Take corrective action to improve the product integration strategy. [PA147.IG101.SP101.SubP108]

9. Assess the product integration strategy on a continuing basis. [PA147.IG101.SP101.SubP109]

10. Manage the changes and distribution of the information about the product integration strategy. [PA147.IG101.SP101.SubP110]

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 how to develop a product integration environment or how to buy or reuse one. *[PA147.IG101.SP102.R101]*

The product integration strategy may identify needs for an environment that must be acquired or developed. This may yield requirements for the purchase or development of equipment, software, or other resources. These requirements are provided to the Requirements Development process area for development. The product integration environment may include the reuse of existing organizational resources. In this case, the strategy should outline the use of these resources and arrangements for their use must be made. The decision to acquire or develop the product integration environment is conducted in the Technical Solution process area. If the decision is to develop the product integration environment, the other practices in Technical Solution and all other process areas involved in conducting a development project are used. [PA147.IG101.SP102.N101]

The environment required at each step of the product integration process may include test equipment, simulators (taking the place of non-available 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]
4. Initiate a project to develop the integration environment if it 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 Define Detailed Product Integration Procedures

Define detailed procedures and criteria for integration of the product components. *[PA147.IG101.SP103]*

As the product integration strategy matures, detailed procedures, inputs, outputs, expected results, and progress criteria are needed. [PA147.IG101.SP103.N101]

Detailed 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]

Detailed criteria can include criteria indicating the readiness of a product component for integration or its acceptability. [PA147.IG101.SP103.N103]

For example, the probability of proper functioning, the delivery rate and its variation, the lead time from order to delivery, personnel availability, availability of the integration facility/line/environment. [PA147.IG101.SP103.N105]

Detailed criteria can be defined for how the product components are to be verified and the functions it is expected to have. Details can be defined for how the assembled product components and final integrated product are to be validated and delivered. [PA147.IG101.SP103.N106]

Detailed criteria may also include the degree of simulation permitted for a product component to pass a test or the detailed criteria for the environment for the integration test. [PA147.IG101.SP103.N104]

Typical Work Products

1. Detailed product integration procedures [PA147.IG101.SP103.W101]
2. Detailed product integration criteria [PA147.IG101.SP103.W102]

Subpractices

1. Establish and maintain detailed product integration procedures for the product components. [PA147.IG101.SP103.SubP101]
2. Establish and maintain the detailed criteria for product component integration and evaluation. [PA147.IG101.SP103.SubP102]
3. Establish and maintain the detailed criteria for validation and delivery of the integrated product. [PA147.IG101.SP103.SubP103]

SG 2 Ensure Interface Compatibility [PA147.IG102]

The product component interfaces, both internal and external, are compatible.

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]

For Software Engineering

In the message category for software, interfaces would include the following: *[PA147.IG102.SP101.SubP101.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.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)*
- *Man-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])*

Consider all the product components and prepare a relationship table mapping. 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 man-machine or human interface. [PA147.IG102.SP101.SubP101.N101]

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]*

Refer to the Requirements Development process area for more information about requirements for interfaces. *[PA147.IG102.SP102.R101]*

Refer to the Technical Solution process area for more information about design of interfaces between product components. *[PA147.IG102.SP102.R102]*

Refer to the Requirements Management process area for more information about managing the changes to the interface requirements. *[PA147.IG102.SP102.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.R104]*

Management of the interfaces includes the maintenance of the consistency of the interfaces throughout the development cycle 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 captured, maintained, and readily accessible. [PA147.IG102.SP102.N103]

Typical Work Products

1. Table of relationships between the product components and the external environment (e.g., main power supply, fastening product, computer bus system, etc.) [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 interface updating [PA147.IG102.SP102.W105]
6. Application Program Interface [PA147.IG102.SP102.W106]
7. Updated interface description or agreement [PA147.IG102.SP102.W107]

Subpractices

1. Ensure the compatibility of the interfaces throughout the development cycle. [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 [PA147.IG103]

Verified product components are assembled and the integrated, verified, and validated product is delivered.

Integration of product components proceeds according to the product integration strategy. 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 inter-operation. 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 strategy. The timely receipt of needed product components and the involvement of the right people contribute to the successful integration of the product components that comprise 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 identifed, 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 practice is to ensure that the properly identified product component that meets its description can actually be assembled according to the product integration strategy. The product components are checked for quantity, obvious damage, and consistency between the product component and interface descriptions. [PA147.IG103.SP101.N101]

Although unit tests are conducted in Technical Solution, verifications are conducted in Verification, and other assurances are conducted in Process and Product Quality Assurance, the ultimate responsibility for checking to make sure everything is proper with the product components before assembly is the responsibility of Product Integration. [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 strategy. [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 metrics) 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 strategy. *[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]*

The assembly and checkout activities of the next 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. Record all appropriate information (e.g., configuration status, serial numbers of the elements, types and calibration date of the meters). [PA147.IG103.SP102.SubP103]

4. Revise the product integration strategy as appropriate. [PA147.IG103.SP102.SubP104]

SP 3.3 Checkout Assembled Product Components

Checkout an assembly of product components. *[PA147.IG103.SP103]*

The activity of checkout is used here as the action of examining and evaluating something for performance, suitability, or readiness and is not to be confused with the activity used in configuration management processes. The checkout activity is performed as appropriate for the stages of assembly of product components as identified in the product integration strategy. The product integration strategy may define a more refined integration sequence than might be envisioned just by examining the product architecture. For example, if an assembly of product components were composed of four less complex product components, the integration sequence will not necessarily call for the simultaneous integration and checkout of the four units as one. Rather, the four less complex units may be integrated progressively, one at a time, with a checkout after each assembly operation prior to realizing the more complex product component that matched the specification in the product architecture. Alternately, the strategy could have determined that only a final check was the best one to perform. [PA147.IG103.SP103.N101]

The adjustment required to fit components together in the factory could be different from the one required to fit 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.SP103.N102]

Typical Work Products

1. Checked out assembled product or product components [PA147.IG103.SP103.W101]
2. Exception reports [PA147.IG103.SP103.W102]
3. Interface checkout reports [PA147.IG103.SP103.W103]
4. Product integration summary reports [PA147.IG103.SP103.W104]

Subpractices

1. Conduct the checkout of assembled product components following the product integration strategy. [PA147.IG103.SP103.SubP101]
2. Record the checkout 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)
- Checkout 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:
(Packaging and delivery methods are documented, either directly or by reference, in the project's defined process.)
[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 (more like a checkout procedure). 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 a product integration strategy and 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 requirements and objectives, and plans for performing the product integration process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are described in the plan for product integration. This plan for product integration differs from the product integration strategy described in the specific practices in this process area. The product integration strategy addresses individual product integration requirements (e.g., sequencing, environment, interfaces, procedures.), whereas the plan for product integration ensures that the planning needed to define those requirements occurs, as well as the planning for interface management, assembly, and the other activities of this process area [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 tools used to perform the activities of the Product Integration process area include the following: [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 methods
- Organization's facilities for integration and assembly
- Assembly methods
- Packaging standards

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
- Checked out assembled product and product components
- Product integration strategy
- 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:

For engineering-related processes, consider stakeholders among 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: [PA147.EL121]

- Reviewing interface descriptions for completeness
- Establishing the product integration strategy
- Assembling and delivering the product and product components
- Communicating the results after checkout
- Communicating new, effective product integration practices 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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Product Integration process area include the following: [PA147.EL112]

- Product component integration profile (e.g., product component assemblies planned, performed, and number of exceptions found)
- Integration checkout problem report trends (e.g., number written and number closed)
- Integration checkout 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 and the work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA147.EL114]

- Establishing and maintaining a product integration strategy
- Ensuring interface compatibility
- Assembling product components and delivering the product.

Examples of work products reviewed include the following: [PA147.EL119]

- Product integration strategy
- 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 assure that selected work products meet their specified requirements. [PA150]

Introductory Notes

Verification encompasses 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 since 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]

Verification of work products at each level of the product 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 assures "you built it right;" whereas, validation assures "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: [PA150.N109]

- Inspections
- Structured walkthroughs

The specific work products that will undergo a peer review are identified in the project's defined process and planned as part of the project planning activities as described in the Integrated Project Management process area. [PA150.N108]

Related Process Areas

Refer to Integrated Project Management (IPPD) process area for more information about what work products will be selected for verification. *[PA150.R101]*

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 Establish a Verification Strategy
- SP 1.2 Establish the Verification Environment
- SP 1.3 Establish Detailed Verification Plans

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
- SP 3.3 Perform Re-Verification

GG 3 Institutionalize a Defined Process
- 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 [PA150.IG101]

Preparation for verification is conducted.

For comprehensive verification, preparation is required to assure that all levels of verification are conducted. Verification includes inspection, testing, analyses, and demonstration. This up-front preparation is also necessary to ensure that verification provisions are embedded in product and product component requirements, designs, and developmental plans and schedules. [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 Establish a Verification Strategy

Establish and maintain a verification strategy for selected work products. *[PA150.IG101.SP101]*

Refer to the Integrated Project Management (IPPD) process area for more information about identifying work products for peer review.
[PA150.IG101.SP101.R101]

For Software Engineering

Examples of verification methods include the following:
[PA150.IG101.SP101.AMP101]

- *Path coverage testing*
- *Load, stress, and performance testing*
- *Decision table based testing*
- *Functional decomposition based testing*
- *Test case reuse*
- *Alpha and Beta test*
- *Operational scenario testing*
- *Acceptance tests*

For Integrated Product and Process Development

The verification strategy should be developed concurrently and iteratively with the product and product component designs. *[PA150.IG101.SP101.AMP102]*

The verification strategy is created to derive the specific activities related to verifying work products. These result in detailed strategies and procedures for the verification of the work products.
[PA150.IG101.SP101.N101]

The requirements and strategies for verification are typically documented in a verification strategy. The verification strategy addresses the specific actions, resources, and environments required for work product verification. This differs from the verification plans addressed by the Plan the Process generic practice. The generic practice addresses the process tasks, who is responsible for them, and resources generally needed. The verification strategy defines the technical approach to work product verification and the specific approaches that will be used to verify specific work products.
[PA150.IG101.SP101.N102]

The verification strategy typically begins with involvement in the definition of product and product component requirements to ensure that these requirements are verifiable. This strategy includes ensuring that an appropriate method of verification is assigned to each requirement when necessary, and verification criteria are developed. At a minimum, a method of verification is assigned to each selected work product. [PA150.IG101.SP101.N103]

The verification strategy may address peer reviews. The specific work products that will undergo a peer review are typically identified in the project plan. [PA150.IG101.SP101.N104]

Typical Work Products

1. Verification strategy [PA150.IG101.SP101.W101]
2. Commercial off-the-shelf (COTS) verification strategy [PA150.IG101.SP101.W102]
3. Verification procedures [PA150.IG101.SP101.W103]
4. Verification criteria [PA150.IG101.SP101.W104]

Subpractices

1. Define the requirements for a realistic verification environment. [PA150.IG101.SP101.SubP102]
2. Identify the verification methods and processes that are available for use. [PA150.IG101.SP101.SubP103]

SP 1.2 Establish the Verification Environment

Establish and maintain the environment needed to support verification. *[PA150.IG101.SP102]*

An environment needs to 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 verification criteria and the verification method 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 support equipment [PA150.IG101.SP102.W101]
2. 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 Detailed Verification Plans

Establish and maintain detailed verification plans for selected work products. *[PA150.IG101.SP103]*

Subpractices

1. Plan the set of comprehensive, integrated verification activities for work products and any COTS products, as necessary. [PA150.IG101.SP103.SubP101]
2. Develop and refine the verification criteria when necessary. [PA150.IG101.SP103.SubP102]
3. For verification of each work product, define which method and process will be used (globally or for each of their requirements). [PA150.IG101.SP103.SubP103]
4. Identify the expected results and any tolerances allowed in the observation and other criteria for satisfying the requirements. [PA150.IG101.SP103.SubP104]
5. Identify any equipment and environmental components needed to support verification. [PA150.IG101.SP103.SubP105]

SG 2 Perform Peer Reviews [PA150.IG102]

Peer reviews are performed on selected work products.

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. Re-review criteria [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 practices 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 a re-review of the work product. [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 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]

Examples of related information include the following: [PA150.IG102.SP101.SubP108.N101]

- The plan for the peer review
- Objectives of the work product
- Applicable standards
- Relevant inputs to the work product (e.g., the relevant requirements for a design)
- Checklists

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 in the life cycle. Peer reviews are performed incrementally, as work products are being developed, not at the end of the cycle. These reviews are structured and are not management reviews. [PA150.IG102.SP102.N101]

Peer reviews are performed on key work products of specification, design, test, and implementation activities and/or specific planning work products (e.g., software development plan, risk management plan, or test plan). [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 are 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. Capture the results of the peer review and document 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 data collection practices. [PA150.IG102.SP102.SubP104.R101]

5. Identify action items and communicate the issues to stakeholders. [PA150.IG102.SP102.SubP105]

Refer to the Requirements Development process area where appropriate to address the action items identified in the peer reviews. [PA150.IG102.SP102.SubP105.R101]

Refer to the Technical Solution process area where appropriate to address the action items identified in the peer reviews. [PA150.IG102.SP102.SubP105.R102]

Refer to the Product Integration process area where appropriate to address the action items identified in the peer reviews. [PA150.IG102.SP102.SubP105.R103]

6. Plan a re-review of the work product if the re-review criteria are satisfied. [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 information about analyzing peer review 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, size of the product, 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 [PA150.IG103]

Selected work products are verified against their specified requirements.

SP 3.1 Perform Verification

Perform verification according to the verification strategy.
[PA150.IG103.SP101]

Verifying products and work products incrementally promotes early detection of problems and can remove defects early. These results of verification save considerable cost of fault isolation and rework associated with troubleshooting problems. [PA150.IG103.SP101.N101]

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 Verified" procedures log [PA150.IG103.SP101.W104]

Subpractices

1. Verify COTS and reused components to verify that they meet the requirements. [PA150.IG103.SP101.SubP101]

2. Perform product verification against the requirements according to the verification strategy and procedures. [PA150.IG103.SP101.SubP102]

3. Capture the results of verification activities. [PA150.IG103.SP101.SubP103]

4. Identify action items resulting from verification of work products. [PA150.IG103.SP101.SubP104]

5. Document the "as-run" verification method and the deviations from the strategies and procedures made 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]

Analysis reports or "as-run" method documentation may also indicate that bad verification results are due to method problems, criteria problems, or an infrastructure problem. [PA150.IG103.SP102.N103]

Refer to the corrective action practices of Project Monitoring and Control process area for implementing corrective action.
[PA150.IG103.SP102.N103.R101]

Typical Work Products

1. Analysis report (such as statistics on performances, causal analysis of non-conformances, comparison of the behavior between the real product and models, trends, etc.) [PA150.IG103.SP102.W101]

2. Trouble reports [PA150.IG103.SP102.W102]

3. Method, criteria, and infrastructure change requests [PA150.IG103.SP102.W103]

4. Corrective actions to verification methods, criteria, and/or infrastructure [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, criteria, and/or infrastructure. [PA150.IG103.SP102.SubP102]

3. Analyze the verification data on defects. [PA150.IG103.SP102.SubP103]

4. Capture all results of the analysis into 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/or infrastructure) and formalize it in a plan. [PA150.IG103.SP102.SubP106]

SP 3.3 Perform Re-Verification

Perform re-verification of corrected work products and ensure that work products have not been negatively impacted. *[PA150.IG103.SP103]*

Re-verification is done to ensure that the defect has been corrected, and to ensure that the work product has not been corrupted as a result of defect-correction actions. [PA150.IG103.SP103.N101]

Re-verification will typically focus in detail on the part of the work product where the defect was detected. However, the work product that was being verified when the defect was detected will need to be re-verified to the extent needed to ensure that no new defects have been introduced. [PA150.IG103.SP103.N103]

Re-verification is also necessary when there are changes in the requirements and/or the designs. [PA150.IG103.SP103.N104]

Re-verification may be necessary when problems have been detected on the verification method. (See the "Perform Verification" specific practice.) [PA150.IG103.SP103.N105]

Typical Work Products

1. Re-verification results [PA150.IG103.SP103.W101]
2. Subsystem and component verification results [PA150.IG103.SP103.W102]
3. System verification results [PA150.IG103.SP103.W103]

Subpractices

1. Identify where re-verification is necessary. [PA150.IG103.SP103.SubP101]
2. Perform re-verification. [PA150.IG103.SP103.SubP102]
3. Perform re-test, as appropriate, including regression testing. [PA150.IG103.SP103.SubP103]

For Software Engineering

Perform regression testing, as appropriate, whenever the software that is being tested changes or the software environment changes. *[PA150.IG103.SP103.SubP103.AMP101]*

4. Supplement or correct the documentation describing the verification activities. [PA150.IG103.SP103.SubP104]

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 a verification strategy and environment, and 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 requirements and objectives, and plans for performing the verification process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are described in the plan for verification. This plan for verification differs from the verification strategy described in the specific practices in this process area. The verification strategy addresses specific actions, resources, and environments required for work product verification, whereas the plan for verification addresses high-level planning for all the verification. [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:

Examples of tools used to perform the activities of the Verification process area include the following: [PA150.EL103]

- Test management tools
- Test case generators
- Test coverage analyzers
- Simulators

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 those skilled in the use of the equipment). [PA150.EL104]

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]

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 strategy
- 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:

For engineering processes, consider stakeholders among 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: [PA150.EL114]

- Establishing a verification strategy
- Conducting peer reviews
- Assessing verification results and identify corrective action

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the verification process against the plan and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Verification process area include the following: [PA150.EL107]

- Verification profile (e.g., the number of verifications planned, performed, and 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 and the work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA150.EL109]

- Establishing and maintaining a verification strategy
- Performing peer reviews
- Verifying selected work products

Examples of work products reviewed include the following: [PA150.EL112]

- Verification strategy
- 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 demonstrates that the as-built product actually performs its intended function(s) in its intended environment. [PA149.N101]

Validation activities use approaches similar to verification (e.g., test, analysis, simulation, etc.). Both validation and verification activities often run concurrently and may use portions of the same environment. The difference is that verification demonstrates compliance with requirements, while validation demonstrates satisfactory suitability for use in the intended operating environment. In other words, verification assures "you built it right;" whereas validation assures "you built the right thing." [PA149.N102]

Refer to the Verification process area for more information about verification activities. *[PA149.N102.R101]*

Product validation should be accomplished using the actual product operating in its intended environment where possible. The entire environment may be used or only part of it. Validation issues can be discovered early in the development life cycle through the use of early validation activities (such as validation of customer requirements against the operational needs of the customers and end-users). [PA149.N103]

Refer to the Requirements Development process area for more information about requirements validation. Requirements validation practices are included in Requirements Development to ensure early requirements validation activities are performed. *[PA149.N103.R101]*

Validation issues may include the identification of unsatisfactory product requirements or unanticipated or unintended functions or behavior. When issues are identified, they are referred to the Requirements Development, Technical Solution, or Project Monitoring and Control process area's practices for resolution. [PA149.N104]

Related Process Areas

Refer to the Requirements Development process area for more information about requirements generation based on the customer needs and for corrective action when validation issues are identified that affect the product or product component requirements. *[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 and product components meet their requirements. *[PA149.R103]*

Refer to the Decision Analysis and Resolution process area for more information about structured decision making related to deciding on the optimum validation strategy. *[PA149.R104]*

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 Establish a Validation Strategy
- SP 1.2 Establish the Validation Environment
- SP 1.3 Define Detailed Validation Procedures

SG 2 Validate Product or Product Components [PA149.IG102]
- SP 2.1 Perform Validation
- SP 2.2 Capture and Analyze Validation Results

GG 3 Institutionalize a Defined Process
- 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 [PA149.IG101]

Preparation for validation is conducted.

Preparation activities for validation allow for flexibility to the technical approach in the product development effort. Preparation activities include establishing and maintaining a validation strategy, environment, and detailed procedures. The validation strategy may include the validation of only the end product or it may include appropriate levels of the product components that are used to build the product. Any product may be subject to validation including replacement, maintenance, and training products to name just a few. [PA149.IG101.N101]

The environment required to validate the product or product components is prepared according to the strategy. The environment may be purchased or specified, designed, and built. Reuse of all or part of the environment is also described in the validation strategy. The environments used for product integration and verification should be considered in a collaborative effort in the validation strategy to reduce cost and improve efficiency or productivity. [PA149.IG101.N102]

SP 1.1 Establish a Validation Strategy

Establish and maintain a validation strategy. *[PA149.IG101.SP101]*

For Integrated Product and Process Development

The validation strategy should be developed concurrently and iteratively with the product and product component designs. *[PA149.IG101.SP101.AMP101]*

The requirements and strategies for validation are documented in a validation strategy. The validation strategy addresses the specific actions, resources, and environments required for product validation. When planning the validation process (see Project Planning and the Planning generic practice), specific tasks should be included to address the detailed validation strategies and activities needed. The validation strategy not only defines the technical approach to product validation, but also detailed activities and resources. These activities and resources may include facilities, validation equipment, environments, time phasing, resource sharing among validation activities within the project and by other projects within the same organization, etc. This may result in the generation of lower-level product component requirements that are handled by the Requirements Development process area. 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 the environment defined by the strategy. [PA149.IG101.SP101.N101]

A validation strategy should be available early in the development process so that the validation mechanisms are clearly understood and agreed to by the relevant stakeholders. [PA149.IG101.SP101.N102]

The validation strategy and procedures address the development, maintenance, support, and training for the product and product components as appropriate. [PA149.IG101.SP101.N103]

Typical Work Products

1. Validation strategy [PA149.IG101.SP101.W101]

Subpractices

1. Identify the key principles, features, and phases for product or product component validation throughout the development life cycle. [PA149.IG101.SP101.SubP101]

2. Define requirements for a realistic validation environment that covers operation, maintenance, training, and support. [PA149.IG101.SP101.SubP102]

The product must be maintainable and supportable in its intended operational environment. This practice addresses the actual maintenance, training, and support services that may be delivered along with the product. In some cases, this practice may be performed by organizations other than the development organization. [PA149.IG101.SP101.SubP102.N101]

> An example of evaluation of maintenance concepts in the operational environment is a demonstration that maintenance tools are operating in the actual product. [PA149.IG101.SP101.SubP102.N102]

3. Define the evaluation criteria for validation. [PA149.IG101.SP101.SubP103]
4. Review the validation strategy 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 validation strategy may identify needs for an environment that must be acquired or developed. This may yield requirements for the purchase or development of equipment, software, or other resources. These requirements are provided to the Requirements Development process areas for development. The validation environment may include the reuse of existing resources. In this case, the strategy should outline the use of these resources and arrangements for their use 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 or by electronics or by 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 test bed or facility with

actual trunks, switches and systems established for realistic integration and validation trials)

Early development of the validation strategy 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 re-use and modification. [PA149.IG101.SP102.SubP105]
6. Plan the availability of resources in detail. [PA149.IG101.SP102.SubP106]

SP 1.3 Define Detailed Validation Procedures

Define detailed procedures and criteria for validation. *[PA149.IG101.SP103]*

Validation procedures 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 detailed validation procedures include test and evaluation of maintenance, training and support services. [PA149.IG101.SP103.N102]

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 are identified and resolved. [PA149.IG101.SP103.SubP101]

2. Document the environment, operational scenario, procedures, inputs, outputs, and expected results for the validation strategy. [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 [PA149.IG102]

The product or product components are validated to ensure that they are suitable for use in their intended operating environment.

Validation activities should start early in the project and are performed according to the validation strategy. [PA149.IG102.N101]

The validation strategy and procedures are used to validate the product and or product components and any associated maintenance, training and support services using the appropriate validation environment. In some cases, this practice may be performed by organizations other than the development organization. [PA149.IG102.N102]

SP 2.1 Perform Validation

Perform validation according to the validation strategy.

[PA149.IG102.SP101]

To be acceptable to users, the product and product components must perform as expected in their intended operational environment. [PA149.IG102.SP101.N101]

Validation activities are performed and the resulting data is collected according to established plans and procedures. [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]

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 Capture and Analyze Validation Results

Capture and 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 or not the needs were met; and 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 process areas. [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 or 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. Capture 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 establishing and maintaining a validation strategy and environment, and for ensuring that the product and product components are suitable for use 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 requirements and objectives, and plans for performing the validation process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are described in the plan for validation. This plan for validation differs from the validation strategy described in the specific practices in this process area. The validation strategy addresses the specific actions, resources, and environments required for validation, whereas the plan for validation addresses high level planning for all the validation activities. [PA149.EL102]

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 and product components. When necessary, the facilities required for the activities in the Validation process area are developed or purchased. [PA149.EL111]

Examples of tools used to perform the activities of the Validation process area include the following: [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]

- Validation strategy
- Validation procedures
- 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:

For engineering processes, consider stakeholders among 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: [PA149.EL114]

- Establishing the validation strategy
- Reviewing product and product component validation results 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 baselined 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 or trials or test and evaluation
- 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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Validation process area 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]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the validation process and the work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA149.EL110]

- Establishing and maintaining a validation strategy
- Validating product or product components

Examples of work products reviewed include the following: [PA149.EL112]

- Validation strategy
- Validation procedures

10128 **GP 2.10 (VE 2) Review Status with Higher-Level Management**

10129 ***Review the activities, status, and results of the validation process***
10130 ***with higher-level management and resolve issues.*** *[GP112]*

ORGANIZATIONAL PROCESS FOCUS

Maturity Level 3

Purpose

The purpose of Organizational Process Focus is to establish and maintain an understanding of the organization's processes and process assets, and to identify, plan, and implement the organization's process improvement activities. [PA152]

Introductory Notes

The organization's processes include the organization's set of standard processes and the defined processes derived from them. The organization's process assets are artifacts that relate to describing, implementing, and improving processes (e.g., policies, process descriptions, support environments, and process implementation support tools). [PA152.N101]

Candidate improvements to the organization's process assets are obtained from various sources, including measurement of the processes, lessons learned in implementing the processes, results of process assessments, results of process and product verification 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 responsibility of facilitating and managing the organization's process improvement activities 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. At the highest level, the organization's planning for Process Improvement results in a Process Improvement Plan. This plan provides the overall process improvement strategy that the organization will use. This strategy may call for more focused, detailed implementation plans such as Assessment Plans, Process Action Plans, Pilot Plans, and Deployment Plans. Assessment Plans describe the assessment timeline and schedule, the scope of the assessment, the resources required to perform the assessment, the reference model against which the assessment will be performed, the logistics for the assessment, etc. Process Action Plans usually result from assessments or evaluations, and document how specific improvements targeting the weaknesses uncovered by an assessment 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 ready for deployment, a Deployment Plan is used. This plan describes when and how the improvement will be deployed across the organization. [PA152.N104]

The organization's process assets are used to establish, maintain, implement, and improve the defined processes that are tailored from the organization's set of standard processes. [PA152.N105]

Related Process Areas

Refer to the Organizational Process Definition process area for more information about the organization's 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, process assets are deployed, and process-related experiences are incorporated into the organization's 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 Assess 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 Process and Related Process Assets
- SP 2.4 Incorporate Process-Related Experiences into the Organization's Process Assets

GG 3 Institutionalize a Defined Process

- 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 [PA152.IG101]

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

Strengths, weaknesses, and improvement opportunities may be determined relative to a process standard or model such as a Capability Maturity Model-Integrated (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 implmentation. Product development processes and product-related process-development 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: *[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 financial, technological, quality, human resource, and marketing issues 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 standard and 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 standards and product standards imposed by the organization
   - Process standards 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 Assess the Organization's Processes

Assess the processes of the organization periodically and as needed to maintain an understanding of their strengths and weaknesses. *[PA152.IG101.SP102]*

Process assessments may be performed for the following reasons: [PA152.IG101.SP102.N101]

- To identify processes that should be improved

- To verify 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 assessment can be eroded significantly if it is not followed by an assessment-based action plan. [PA152.IG101.SP102.N102]

Typical Work Products

1. Plans for the organization's process assessments [PA152.IG101.SP102.W101]
2. Assessment 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 assessment 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 assessment and to provide the resources and funding to analyze and communicate the findings of the assessment. [PA152.IG101.SP102.SubP101.N101]

2. Define the scope of the process assessment. [PA152.IG101.SP102.SubP102]

   Process assessments 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 assessment addresses the following: [PA152.IG101.SP102.SubP102.N102]

   - Definition of the organization (e.g., sites or business areas) that will be covered by the assessment
   - Identification of the project and support functions that will represent the organization in the assessment
   - Processes or process areas that will be assessed

3. Determine the method and criteria for process assessment. [PA152.IG101.SP102.SubP103]

Process assessments can occur in many forms. Process assessments need to address the needs and objectives of the organization, which may change over time. For example, the assessment may be based on a process model, such as a CMMI model, or on a national or international standard, such as ISO 9001. The assessments may also be based on a benchmark comparison with other organizations. The assessment method may assume a variety of characteristics in terms of time and effort expended, makeup of the assessment team, and the method and depth of investigation, for example. [PA152.IG101.SP102.SubP103.N101]

4. Plan, schedule, and prepare for the process assessment. [PA152.IG101.SP102.SubP104]

5. Conduct the process assessment. [PA152.IG101.SP102.SubP105]

6. Document the assessment activities and findings. [PA152.IG101.SP102.SubP106]

SP 1.3 Identify the Organization's Process Improvements

Identify improvements to the organization's processes and related 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 and analyze the processes
   - 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 stakeholders
   - Solicit inputs on process improvements from the senior management and leaders in the organization
   - Examine the results of process assessments 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
- Evaluate the expected improvement against the organization's improvement objectives and priorities
- Determine the potential barriers to the process improvements and 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 looking at the current conditions in the organization versus the optimal conditions
- Force-field analysis of potential improvements to identify potential barriers and strategies for overcoming those barriers Cause/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 [PA152.IG102]

Improvements are planned and implemented, process assets are deployed, and process-related experiences are incorporated into the organization's process assets.

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 related 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 assessments or evaluations. [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 practice. [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 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 others affected 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 Process and Related Process Assets

Deploy the process and related process assets across the organization. *[PA152.IG102.SP103]*

Deployment of a process and related process assets or of changes to an existing process and related process assets should be performed in an orderly manner. Some process assets or changes to process assets may not be appropriate for implementation in some parts of the organization (for example, because of customer requirements or the current life-cycle phase being implemented). 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 process assets is supported and enabled by the existence of an Organizational Support Environment and an Organizational Process Asset Library . *[PA152.IG102.SP103.N101.R101]*

Typical Work Products

1. Plans for deploying the process assets and changes to process assets [PA152.IG102.SP103.W101]
2. Training materials for deploying the process assets and changes to process assets [PA152.IG102.SP103.W102]
3. Documentation of changes to the process assets [PA152.IG102.SP103.W103]
4. Support materials for deploying the process assets and changes to process assets [PA152.IG102.SP103.W104]

Subpractices

1. Deploy 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 process assets that should be adopted by those who will be performing the process
   - Ensuring that training for the process assets that are being deployed is available
   - Identifying the support resources (e.g., tools) needed to transition the deployed process assets
   - Determining the schedule for deploying the 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 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 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 process assets. [PA152.IG102.SP103.SubP104]

SP 2.4 Incorporate Process-Related Experiences into the Organization's Process Assets

Incorporate process-related work products, measures, and improvement information derived from planning and performing the process into the organization's 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 organization process assets [PA152.IG102.SP104.W103]
4. Improvement recommendations for the organization's process assets [PA152.IG102.SP104.W104]
5. Records of the organization's process improvement activities [PA152.IG102.SP104.W105]
6. Information on the organization's 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 process assets that are relative to the organization's business objectives. [PA152.IG102.SP104.SubP101]

2. Obtain feedback about the use of the process assets. [PA152.IG102.SP104.SubP102]

3. Derive lessons learned from defining, piloting, implementing, and deploying the 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]

   - To evaluate the performance of people
   - To judge 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. Evaluate the processes, methods, and tools in use in the organization and develop recommendations for improving the organization's process assets. [PA152.IG102.SP104.SubP106]

   This evaluation 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
   - Evaluating the quality and effectiveness of the organization's process assets
   - Identifying candidate improvements to the organization's 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 of the processes being used, and planning and implementing process improvement activities across the organization. [PA152.EL101]

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 requirements and objectives, and plans for performing the organizational process focus process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are described in the organization's plan for process improvement (Process Improvement Plan). This plan for process improvement differs from the process action plans described in the specific practices in this PA. The process action plans address the tactical, short-term improvements for the organization; whereas the plan for process improvement addresses the overall process improvement strategy for the organization. [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 tools used in performing the activities of the Organizational Process Focus process area include the following: [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 (e.g., the Engineering Process Group or EPG) 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 process assets
- Plans for the organization's process assessments

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: [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
- Assessing the organization's processes
- Implementing process action plans
- Coordinating and collaborating on the execution of pilots to test selected improvements
- Deploying process assets and changes to 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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Organizational Process Focus process area 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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 assessments

10729 **GP 2.10 (VE 2) Review Status with Higher-Level Management**

10730 ***Review the activities, status, and results of the organizational***
10731 ***process focus process with higher-level management and resolve***
10732 ***issues.*** *[GP112]*

10733 Elaboration:

10734 These reviews are typically in the form of a briefing presented to the
10735 Management Steering Committee by the Process Group and the
10736 process action teams. [PA152.EL116]

10737 Examples of presentation topics include the following: [PA152.EL121]

10738 • Status of Improvements being developed by process action teams

10739 • Results of pilots

10740 • Results of deployments

10741 • Schedule status for achieving significant milestones (e.g.,
10742 readiness for an assessment, or progress towards achieving a pre-
10743 defined organizational maturity or process capability level)

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

These process assets include the organization's set of standard processes and supporting assets. These assets enable consistent process performance across the organization and provide a basis for cumulative, long-term benefits to the organization. [PA153.N101]

The organization's process assets are artifacts that relate to describing, implementing, and improving processes (e.g., policies, 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. [PA153.N102]

The organization's process asset library is a collection of items maintained by the organization, for use by the people in the organization in developing, tailoring, maintaining, implementing, managing, and improving their processes. These process assets include descriptions of processes and process elements, descriptions of life-cycle models, process tailoring guidelines, process-related documentation, and data. These process assets support organizational learning and process improvement by allowing the sharing of "best practices" process assets, 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 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 and standard processes. [PA153.N105]

The organization's 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 library of process-related assets 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 **Create Organizational Process Assets** [PA153.IG101]

A set of organizational process assets is available.

SG 2 **Make Supporting Process Assets Available** [PA153.IG102]

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

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

The process is institutionalized as a defined process.

Practice to Goal Relationship Table

SG 1 Create 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

SG 2 Make Supporting Process Assets Available [PA153.IG102]
- SP 2.1 Establish an Organizational Measurement Repository
- SP 2.2 Establish an Organizational Process Asset Library

GG 3 Institutionalize a Defined Process
- 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 Create Organizational Process Assets [PA153.IG101]

A set of organizational process assets is available.

For Integrated Product and Process Development

Integrated processes that emphasize parallel, rather than serial development, are a cornerstone of IPPD implmentation. Product development processes and product-related process-development 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 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 organization's 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 are tailored by individual organizations (e.g., division or site) in the enterprise to establish their set of standard processes. Within an organization there may be a different set of standard processes, tailored for each of the business areas or product lines. The organization's set of standard processes refers to the standard processes established at the organization level and standard processes that may be established at lower-levels in the organization (e.g., business areas or product lines). Some organizations may only have a single level of standard processes for the organization. [PA153.IG101.SP101.N101]

Multiple standard processes may be needed to address the needs of different application domains, life cycles, 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. A process element is the atomic unit of a process definition. [PA153.IG101.SP101.N102]

The organization's set of standard processes typically includes technical, management, administrative, support, and organizational processes. [PA153.IG101.SP101.N103]

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

In these practices, the rules for describing the relationships among process elements are referred to as a "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 adhere to the applicable policies, process standards, and product standards. [PA153.IG101.SP101.SubP104]

Examples of requirements include the following: [PA153.IG101.SP101.SubP104.N101]

- Interoperability of tools
- Criteria for revising and retiring process elements
- Use of common terminology
- Consistency with designated style manual
- Use of common phrases (e.g., "in accordance with")
- Use of abbreviations
- Security classification markings
- Format/packaging of process documentation

5. Ensure that the organization's set of standard processes satisfy 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 each of the organization's set of standard processes integrate appropriately with other 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 process 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. [PA153.IG101.SP102.N101]

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. These help guide projects through the major steps of identifying customer needs; planning; defining and designing the products and services; developing the products; verifying; validating; providing the products and services; and installing, operating, supporting and retiring the product. [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 process-related needs of the project and the needs of the organization. [PA153.IG101.SP102.SubP101]

Examples of development life-cycle models include the following: [PA153.IG101.SP102.SubP101.N101]

- Waterfall
- Spiral
- Evolutionary
- Incremental
- Iterative

Examples of project characteristics that could affect the 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
- Developmental 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 whether it is done serially after the product has been developed or in parallel with the development of the product, as in IPPD. Processes, for example 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 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 organization's 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 process tailoring and documentation of tailoring performed

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]

For processes performed at the organizational level, the standard process may be the defined process, so tailoring may not be needed. [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 the specific process characteristics and needs

Examples of tailoring actions include: [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]

SG 2 Make Supporting Process Assets Available [PA153.IG102]

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

SP 2.1 Establish an Organizational Measurement Repository

Establish and maintain an organizational measurement repository *[PA153.IG102.SP101]*

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.IG102.SP101.N101]

Typical Work Products

1. Definition of the common set of product and process measures for the organization's set of standard processes [PA153.IG102.SP101.W101]
2. Organization's measurement repository (i.e., the repository structure and support environment) [PA153.IG102.SP101.W102]
3. Organizational measurement data [PA153.IG102.SP101.W103]

Subpractices

1. Determine the organization's needs for storing, retrieving, and analyzing measurements. [PA153.IG102.SP101.SubP101]
2. Define a common set of process and product measures for the organization's set of standard processes. [PA153.IG102.SP101.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.IG102.SP101.SubP102.N101]

   Operational definitions for the measures specify the point in the process where the data will be collected and the procedures for collecting valid data. [PA153.IG102.SP101.SubP102.N102]

Examples of classes of commonly used measures include the following:
[PA153.IG102.SP101.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 or verification coverage
- Reliability measures (e.g., mean time to failure)

Refer to the Measurement and Analysis process area for more information about defining measures *[PA153.IG102.SP101.SubP102.N103.R101]*

3. Design and implement the measurement repository.
[PA153.IG102.SP101.SubP103]

4. Specify the procedures for storing, updating, and retrieving.
[PA153.IG102.SP101.SubP104]

5. Conduct peer reviews on the definitions of the common set of measures and the procedures for storing and retrieving measures.
[PA153.IG102.SP101.SubP105]

Refer to the Verification process area for more information about conducting peer reviews. *[PA153.IG102.SP101.SubP105.R101]*

6. Enter the specified measures into the repository.
[PA153.IG102.SP101.SubP106]

Refer to the Measurement and Analysis process area for more information about collecting and analyzing data. *[PA153.IG102.SP101.SubP106.R101]*

7. Make the contents of the process measurement repository available for use by the organization and projects as appropriate.
[PA153.IG102.SP101.SubP107]

8. Revise the measurement repository, common set of measures, and procedures as the organizational needs change. [PA153.IG102.SP101.SubP108]

The following are examples of when the common set of measures may need to be revised. [PA153.IG102.SP101.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 2.2 Establish an Organizational Process Asset Library

Establish and maintain the organization's library of process-related assets. *[PA153.IG102.SP102]*

Examples of process-related documentation include the following: [PA153.IG102.SP102.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. Organization's library to store the process-related documentation (i.e., the library structure and support environment) [PA153.IG102.SP102.W101]
2. Best examples of process-related documentation items [PA153.IG102.SP102.W102]
3. Catalog of process documentation items [PA153.IG102.SP102.W103]

Subpractices

1. Design and implement the library of process assets, including the library structure and support environment. [PA153.IG102.SP102.SubP101]
2. Specify the criteria for including documentation items in the library. [PA153.IG102.SP102.SubP102]

The documentation items are selected based primarily on their relationship to the organization's set of standard processes. [PA153.IG102.SP102.SubP102.N101]

3. Specify the procedures for storing and retrieving documentation items. [PA153.IG102.SP102.SubP103]

4. Enter the selected documentation items into the library and catalog them for easy reference and retrieval. [PA153.IG102.SP102.SubP104]

5. Make the documentation items available for use by the projects. [PA153.IG102.SP102.SubP105]

6. Periodically review the use of each documentation item and use the results to maintain the library contents. [PA153.IG102.SP102.SubP106]

7. Revise the library of process-related assets as necessary. [PA153.IG102.SP102.SubP107]

The following are examples of when the library may need to be revised: [PA153.IG102.SP102.SubP107.N101]

- New process assets are added
- Process assets are retired
- Current versions of documentation 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 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 requirements and objectives, and plans for performing the organizational process definition process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are typically described in the organization's plan for process improvement. [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 (e.g., an engineering process group or EPG) typically manages the organizational process definition activities. This group is typically staffed by a core of engineering 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 tools used in performing the activities of the Organizational Process Definition process area include the following: [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

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]*

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
- Organizational 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: [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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Organizational Process Development process area 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]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational process definition process and the work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA153.EL105]

- Creating organizational process assets
- Making supporting process assets available

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
- Organizational 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 both the organization's strategic business objectives and 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, etc.), 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, guided self-study, or 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 knowledge and skill 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 "projects 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 Identify Training Needs and Make Training Available [PA158.IG101]

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

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 Identify Training Needs and Make Training Available [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 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

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 Identify Training Needs and Make Training Available [PA158.IG101]

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

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 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
- Company-level initiatives and standards
- 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 required 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. Project 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 project 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 groups 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 Organizational Training Tactical Plan

Establish and maintain an organizational training tactical plan. *[PA158.IG101.SP103]*

The Organizational Training Tactical Plan is a periodic, tactical plan for delivering training and assessing its 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, skill 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 providing 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 acquiring 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. 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

5. Revise the training materials and supporting artifacts as necessary.
[PA158.IG101.SP104.SubP105]

Examples of when the training materials and supporting artifacts may need to be revised include the following: [PA158.IG101.SP104.SubP105.N101]

- When training needs change (e.g., when new technology associated with the training topic is available)
- When an evaluation of the training identifies the need for change (e.g., evaluations of training effectiveness surveys, training program performance assessments, instructor evaluation forms, etc.)

SG 2 Provide Necessary Training [PA158.IG102]

Training necessary for individuals to perform their roles effectively is provided.

In selecting people to be trained, the following considerations need to be made: [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 to 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 an organizational training 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, instructors, etc.). [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 regards 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 the manager responsible should approve the waiver for organizational training as well as by the manager of the excepted individual. [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 work objectives of both the project and organization. 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 written unambiguously where the performance requirements are stated in a manner that makes them observable and verifiable. The results of the training effectiveness assessment should be used to revise training materials as described in "Establish Training Capability" 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 was 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 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 requirements and objectives, and plans for performing the organizational training process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are typically included in the plan for the organizational training process. This plan for organizational training differs from the organizational training plan described in the specific practice in this process area. The plan for organizational training addresses strategic high-level planning for all the organizational training activities. The organizational training plan addresses periodic, training needs. [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 tools used in performing the activities of the Organizational Training process area include the following: [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

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]*

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: [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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Organizational Training process area 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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 (IPPD)

Maturity Level 3

Purpose

The purpose of Integrated Project Management (IPPD) 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. It 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]

Introductory Notes

The integrated and defined process that is tailored from the organization’s set of standard is called the project’s defined process. [PA167.N101]

Integrated Project Management (IPPD) involves the following: [PA167.N102]

- Tailoring the project's defined process from the organization's set of standard processes.
- 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.
- Managing the project using the project’s defined process.
- Using and contributing to the organization's process assets.
- Enabling each relevant stakeholder’s unique expertise and concerns to be identified, considered, and implemented during the development of the product.
- Ensuring that the relevant stakeholders associated with the project coordinate their efforts in a timely manner: (1) to address product and product component requirements, plans, objectives, issues, and risks; (2) to make their commitments; and (3) to identify, track, and resolve issues.

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 is typically described in the project plan. Certain activities may be covered in other subordinate plans, such as the quality assurance plan, verification strategy, 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 term relevant stakeholder in this process area refers to a group or individual that is affected by or is in some way accountable for the outcome of the project. A relevant stakeholder could be an individual from another project or team, individuals representing technical or support activities, suppliers, customers, or end users. [PA167.N106]

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 these relevant stakeholders to ensure that everyone involved in the project is appropriately aware of the status and plans of all activities, and that project coordination issues receive appropriate attention. In defining the project's defined process, formal interfaces are created as necessary to ensure that appropriate coordination and collaboration occurs. [PA167.N107]

This process area applies in any organizational structure, including projects that are structured as line organizations, matrix organizations, integrated teams (also known as Integrated Product Teams [IPTs]). The terminology should be appropriately interpreted for the organizational structure in place. [PA167.N108]

If you are using the continuous representation, the first goal in this process area may be redundant when applying the capability level three generic practices to project-related process areas. However, the practices, subpractices, and notes will provide many details that will assist you with this application. [PA167.N109]

Related Process Areas

Refer to the Project Planning process area for more information about practices that cover the planning of the project. *[PA167.R101]*

Refer to the Project Monitoring and Control process area for more information about the practices that cover 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 the organization's set of standard processes, process assets, and tailoring guidelines. *[PA167.R105]*

Refer to the Measurement and Analysis process area for more information about 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 and 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** [PA167.IG103]

The project is conducted using the project's shared vision.

SG 4 Organize Integrated Teams [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 Organization's 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 [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 [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
- 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 [PA167.IG101]

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

The project's defined process must include those standard processes elements from the organization's set of standard processes and guidelines that are unique to IPPD. For example the defined processes are not only integrated but reflect a parallel, rather than a serial, development process. The product-related 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 organization's set of standard processes, the library of process assets, life-cycle models, and tailoring guidelines. *[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 is a set of defined processes and subprocesses that form an integrated, coherent life cycle for the project. [PA167.IG101.SP101.N101]

The project's defined process includes 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. 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 organization's 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 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 library of process assets 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 organization's 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 subordinate plans 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 practices involved in 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. This plan development also includes accounting for organizational process needs and objectives. [PA167.IG101.SP103.N102]

The plans of the integrated teams are included in this integration. Developing a complete project plan and project's defined process may require an iterative effort if a complex, multi-layered integrated team structure is being deployed. [PA167.IG101.SP103.N103]

Typical Work Products

1. Project plan [PA167.IG101.SP103.W101]
2. Subordinate plans [PA167.IG101.SP103.W102]

Subpractices

1. Integrate the subordinate plans with the project plan.
   [PA167.IG101.SP103.SubP101]

   The subordinate plans may include the following: [PA167.IG101.SP103.SubP101.N101]

   - Quality assurance plans
   - Configuration management plans
   - Risk management strategy
   - Verification strategy
   - Validation strategy
   - Product integration plans
   - 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]

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. [PA167.IG101.SP103.SubP107]

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 between stakeholders involved in the project. [PA167.IG101.SP103.SubP109]

SP 1.4 Manage the Project Using the Integrated Plans

Manage the project using the project plan, the subordinate plans, and the project's defined process. *[PA167.IG101.SP104]*

Refer to the Organizational Process Definition process area for more information about the library of 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 library of process assets. [PA167.IG101.SP104.SubP101]

   This task typically includes the following: [PA167.IG101.SP104.SubP101.N101]

   - Incorporating artifacts from the library into the project as appropriate
   - Using lessons learned from the 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 subordinate plans. [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, roles to be performed by the relevant stakeholders, along with well-defined control mechanisms (e.g., peer reviews), are used to achieve 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 obtaining and analyzing measures.
[PA167.IG101.SP104.SubP103.R101]

4. Periodically review the adequacy of the environment to meet the project's needs and 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 projected 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 Organization's Process Assets

Contribute work products, measures, and documented experiences to the organization's 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 organization's process assets, the organization's measurement repository, and the library of process assets.
[PA167.IG101.SP105.R102]

Typical Work Products

1. Proposed improvements to the organization's 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 organization's 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 description
- 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 library of process assets. [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 library of process assets. [PA167.IG101.SP105.SubP104]

SG 2 Coordinate and Collaborate with Relevant Stakeholders [PA167.IG102]

Coordination and collaboration of the project with relevant stakeholders is conducted.

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 the customer requirements, product and product component requirements, product architecture, and product design) [PA167.IG102.SP101.W102]
3. Recommendations on issues [PA167.IG102.SP101.W103]
4. Documented defects, issues, and action items arising from reviews [PA167.IG102.SP101.W104]
5. Documented product and project interface risks [PA167.IG102.SP101.W105]

Subpractices

1. Coordinate with the relevant stakeholders that 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. Participate in reviews of the activities and work products of other projects as appropriate. [PA167.IG102.SP101.SubP102]

3. Ensure that work products produced to satisfy commitments meet the requirements of the receiving 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

4. 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 on establishing and maintaining commitments. *[PA167.IG102.SP102.R101]*

Typical Work Products

1. Agendas and schedules for collaborative activities [PA167.IG102.SP102.W101]
2. Defects, issues, and action items arising from reviews [PA167.IG102.SP102.W102]
3. Critical dependencies [PA167.IG102.SP102.W103]
4. Commitments to address critical dependencies [PA167.IG102.SP102.W104]
5. 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 taking 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. Documented issues [PA167.IG102.SP103.W101]

2. Status of 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]

SG 3 Use the Project's Shared Vision [PA167.IG103]

The project is conducted using the project's shared vision.

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. Aligned means that 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 as an organizational process asset. *[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 vision with the organization's and helps create a common purpose within which project activities can be coordinated Understanding the interfaces with other stakeholders external to the project, the objectives and expectations of stakeholders (including members of the project), and conditions within which the project must operate), is critical to ensure that the project's direction and activities achieve a fit with any larger objectives. [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 member's 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 behaviors, characteristics, and principles about the organizational and project situation that affect the project's shared vision. [PA167.IG103.SP101.SubP101]
2. Use appropriate techniques to explore project member's mental models and personal 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]*

Refer to the Organizational Environment for Integration process area for more information about the organization's shared vision.

[PA167.IG103.SP102.R101]

A shared vision is created by the project and for the project, in alignment with the organization's shared vision. [PA167.IG103.SP102.N101]

When creating a 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 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 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 vision should be communicated, and agreement and commitment of the relevant stakeholders should be attained. [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 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. Vision and objective statements [PA167.IG103.SP102.W102]
3. Statement of values and principles [PA167.IG103.SP102.W103]
4. Presentations to stakeholders, observers, and management [PA167.IG103.SP102.W104]

5. Communications strategy [PA167.IG103.SP102.W105]
6. Handbook for new members of the project [PA167.IG103.SP102.W106]
7. Presentations to stakeholders and management [PA167.IG103.SP102.W107]
8. Presentations and publications describing principles, vision statement and objectives [PA167.IG103.SP102.W108]
9. Published principles, 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 among those affected by it and participating in its creation. [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 [PA167.IG104]

The integrated teams needed to execute the project are identified, defined, structured, and tasked.

The purpose of this goal and its 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 Integrated Product and Process Development (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 practices, 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 cycle of the product for each work product in that hierarchy. More complex structuring occurs when the WBS is non-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 practices
- 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 vision (created in Specific Goal 3 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 sub teams 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 work breakdown structure 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]

Refer to the Project Planning process area for more information about the Work Breakdown Structure (WBS). [PA167.IG104.SP101.SubP103.R101]

   Each team in the team structure should have specified responsibility for tasks and work products. The team structure should tie to the work breakdown structure (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 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. Additionally, organizational processes about organizing team structures when influenced by risk and product life cycle may be particularly useful. [PA167.IG104.SP101.SubP105.N101]

The project's shared vision may evolve when the integrated team structure is established so that the teams may have some input to the project's shared vision. [PA167.IG104.SP101.SubP105.N102]

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 structured decision making 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 a team structure maintenance perspective, this activity would include assessments of the teams already deployed and candidate alternative structures. [PA167.IG104.SP101.SubP107.N101]

It may be necessary to return to this specific practice if the development in the next specific practice proves to be infeasible. [PA167.IG104.SP101.SubP107.N102]

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 for each integrated team the task and work products, along with their associated requirements and interfaces,for which the team will be responsible. [PA167.IG104.SP102.SubP101.N101]

2. Check that the preliminary distribution of requirements and interfaces covers all specified product and other requirements. [PA167.IG104.SP102.SubP102]

12697 In the event that complete coverage of requirements is not achieved, corrective
12698 action should be taken to redistribute requirements or alter the integrated team
12699 structure. [PA167.IG104.SP102.SubP102.N101]

12700 3. Define responsibilities and authorities for integrated teams.
12701 [PA167.IG104.SP102.SubP103]

12702 Business, management and other non-technical responsibilities and authorities for
12703 the integrated team are necessary elements to proper team function. Integrated
12704 team responsibilities and authorities are normally developed by the project and
12705 are consistent with established organization practices. Such factors include:
12706 [PA167.IG104.SP102.SubP103.N101]

12707 - Authority of teams to pick their own leader
12708 - Authority of teams to implement sub teams (e.g., a product team forming an
12709 integration sub-team)
12710 - Reporting chains
12711 - Reporting requirements (cost, schedule, and performance status)
12712 - Progress reporting metrics and methods

12713 4. Designate the sponsor for each integrated team.
12714 [PA167.IG104.SP102.SubP104]

12715 An integrated team sponsor is a manager (individual or team) that is responsible
12716 for establishing an integrated team, monitoring its activities and progress, and
12717 taking corrective action when needed. A manager may sponsor one or many
12718 teams. [PA167.IG104.SP102.SubP104.N101]

12719 ### SP 4.3 Establish Integrated Teams

12720 ***Establish and maintain teams in the integrated team structure.***
12721 *[PA167.IG104.SP103]*

12722 The teams within the selected and satisfactory integrated team
12723 structure are established. This process encompasses the choosing of
12724 team leaders and the assignment of planned responsibilities and
12725 requirements for each team. It also involves providing the resources
12726 required to accomplish the tasks assigned to the team. [PA167.IG104.SP103.N101]

12727 The integrated team structure is a dynamic entity that must be able to
12728 adjust to changes in people, requirements and the nature of tasks, and
12729 to tackle many difficulties. The integrated team structure should be
12730 continuously monitored to detect malfunctions, mismanaged interfaces,
12731 and mismatches of the work to the staff. Corrective action should be
12732 taken when performance does not meet expectations. [PA167.IG104.SP103.N102]

12733 **Typical Work Products**

12734 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. Performance measures of integrated teams [PA167.IG104.SP103.W105]
6. PPQA 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 ca 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 assure that the resources are adequate and that the people are adequate to carry out the tasks and that they 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]

12767 For each integrated team in the selected structure, create a team that has a
12768 shared vision, charter, and operating principles as described in the Integrated
12769 Teaming process area. Creating the integrated team is a collaborative effort of the
12770 team sponsor and the members of the team. Other stakeholders may be involved
12771 in accord with the plan for stakeholder involvement. The teams that interface with
12772 the target team should be involved to assure that the specified interfaces are
12773 honored. [PA167.IG104.SP103.SubP104.N101]

12774 5. Integrated team composition and structures are periodically
12775 evaluated and modified to best reflect project needs.
12776 [PA167.IG104.SP103.SubP105]

12777 Changes in team structure could include: [PA167.IG104.SP103.SubP105.N101]

12778 • Retiring a team for a period of time (e.g., while long duration manufacturing or
12779 verifications are done)

12780 • Disbanding a team when it is no longer cost–effective in serving the project

12781 • Combining teams to achieve operating efficiencies

12782 • Adding teams as new product components are identified for development.

12783 6. When a change of team leader or a significant change of
12784 membership of the team occurs, review the integrated team
12785 composition and its place in the integrated team structure.
12786 [PA167.IG104.SP103.SubP106]

12787 A change of this kind may significantly affect the ability of the team to accomplish
12788 its objectives. A review of the match between the new composition and the current
12789 responsibilities should be made. If the match is not satisfactory then the team
12790 composition should be changed or the team's responsibility should be modified.
12791 One complication of changed responsibility is that other teams may have to adjust
12792 and add tasks to cover the change. This fact my cause a domino effect in the
12793 team structure. Such a change should be undertaken carefully.
12794 [PA167.IG104.SP103.SubP106.N101]

12795 7. When a change in team responsibility occurs, review the team
12796 composition and its tasking. [PA167.IG104.SP103.SubP107]

12797 These changes often occur as the project moves from one phase to the next. For
12798 example, from completion of detailed design and move into fabrication and
12799 integration of product components is sometimes chosen as a transition point
12800 where less design expertise on teams may be necessary. [PA167.IG104.SP103.SubP107.N101]

12801 8. Manage the overall performance of the teams. [PA167.IG104.SP103.SubP108]

12802 *Refer to the Use the Project's Defined Process specific goal of the*
12803 *Integrated Project Management (IPPD) process area for more*
12804 *information about practices to manage the overall performance of the*
12805 *teams. [PA167.IG104.SP103.SubP108.R101]*

Refer to Project Monitor and Control process area for more information about monitoring the performance of the teams. *[PA167.IG104.SP103.SubP108.R102]*

Refer to the Measurement and Analysis process area for more information about collecting and analyzing performance of the teams. *[PA167.IG104.SP103.SubP108.R103]*

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 (IPPD) process. *[GP103]*

Elaboration:

This policy establishes organizational expectations for using the project's defined process and coordinating and collaborating with relevant stakeholders. It also establishes organizational expectations for using Integrated Product and Process Development concepts for carrying out the objectives of the organization. [PA167.EL101]

Ability to Perform

GP 3.1 (AB 1) Establish a Defined Process

Establish and maintain the description of a defined integrated project management (IPPD) process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the requirements and objectives, and plans for performing the integrated project management (IPPD) process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are described in the plan for integrated project management. This plan differs from the project plan and subordinate plans described in the specific practices in this process area. The project and subordinate plans address the specific needs and objectives for the project; whereas the plan for integrated project management addresses the overall planning of this process area and how the specific practices will be performed. [PA167.EL107]

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the integrated project management (IPPD) process, developing the work products and providing the services of the process. *[GP105]*

Elaboration:

Examples of tools used to perform project management are given in the Project Planning and Project Monitoring and Control process areas. In addition, examples of tools used in performing the activities of the Integrated Project Management (IPPD) process area include the following: [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 (IPPD) process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the integrated project management (IPPD) 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 organization's process assets
- Building the project's shared vision
- Team building
- Integrated management
- Intergroup coordination
- Group problem solving

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the integrated project management (IPPD) 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
- Subordinate plans
- Integrated plans
- Actual process and product measures collected from the project
- Integrated team structure

12892 **GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders**

12893 ***Identify and involve the relevant stakeholders of the integrated***
12894 ***project management (IPPD) process as planned.*** *[GP124]*

12895 Elaboration:

12896 This generic practice is different from managing stakeholder
12897 involvement for the project, which is covered by specific practices within
12898 this process area. [PA167.EL108]

12899 Examples of activities for stakeholder involvement include: [PA167.EL110]

12900 • Resolving issues about the tailoring of the process assets

12901 • Resolving issues among the project plan and the subordinate plans

12902 • Reviewing project performance to align with current and projected
12903 needs, objectives, and requirements

12904 • Creating the project's shared vision

12905 • Defining the integrated team structure for the project

12906

12907 **GP 2.8 (DI 3) Monitor and Control the Process**

12908 ***Monitor and control the integrated project management (IPPD)***
12909 ***process against the plan and take appropriate corrective action.***
12910 *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Integrated Process Management process area 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)
- Project's shared vision usage and effectiveness
- Integrated team structure usage and effectiveness - Select indicators of shared vision effectiveness that show there is unity of purpose within the project, and that the project is working together and meeting its objectives. Indicators should also show that behaviors and principles have been established and are being used while working to achieve the objective and that the shared vision of the project align 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 (IPPD) 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 (IPPD) process and the work products and services of the process to the applicable requirements, objectives, and standards, 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
- Using the project's shared vision

Examples of work products reviewed include the following: [PA167.EL109]

- Project's defined process
- Project plans
- Subordinate plans
- 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 (IPPD) 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 cycle 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 needs to address issues that could endanger critical objectives. A continuous risk management approach is applied to ensure effective anticipation and mitigation of risks with critical impact across the project life cycle. [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 developed in the Project Planning process area. Strong leadership across all affected parties 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 than to modify or revise products or project elements at the middle or end of the development process. [PA148.N103]

Risk management may 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 process area and Project Monitoring and Control process area, 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 practices to systematically plan, anticipate, and mitigate risks to proactively minimize their impact to 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. Risk mitigation strategies should be guided by a shared product vision to ensure the product's perspective is maintained. [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 structured decision-making approach 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, Classify, 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

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 [PA148.IG101]

Preparation for risk management is conducted.

The strategy used to identify, analyze, and mitigate risks is established and maintained. This is typically documented in a project risk management plan. The risk management strategy addresses the specific actions, resources, and management approach used to apply and control the risk management program. This includes planning for 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]

   There are many sources of risks, both internal (e.g., the ability to produce a design, known weaknesses in a process application such as requirements allocation) and external (e.g., funding stability, natural environment) to the project. Some typical important risk areas are as follows: [PA148.IG101.SP101.SubP101.N101]

   - uncertain requirements
   - design feasibility
   - test and evaluation adequacy
   - technology availability
   - support concept
   - producibility
   - overlap of essential activities
   - developer capability
   - cost or funding issues
   - insufficient monitoring
   - unrealistic schedule estimates or allocation
   - inadequate personnel resources
   - safety issues
   - health issues
   - security

Often accepted without adequate planning are many external sources of risk, such as single, limited, and diminishing sources of supply, or the natural environment. Early identification of internal and external sources of risk can result in simple mitigation plans that can be implemented early in the project to preclude occurrence of the risk or reduce the consequences of its occurrence.

[PA148.IG101.SP101.SubP101.N102]

2. Determine risk categories [PA148.IG101.SP101.SubP102]

Risk categories reflect the "bins" for collecting and organizing risks as well as establishing a common set of levels (or categories) that can be applied in assessing each risk. Categories include sources of risk (e.g., technology, environment, manufacturing, and design), and impacts of risk (cost, schedule, and performance). A risk taxonomy framework can be used to collect and organize risks according to common risk classes, elements, and attributes.

[PA148.IG101.SP101.SubP102.N101]

SP 1.2 Define Risk Parameters

Define the parameters used to analyze and classify risks, and the parameters used to control the risk management effort.

[PA148.IG101.SP102]

Parameters for evaluating, classifying, and prioritizing risks include criteria for risk likelihood and consequence levels, thresholds (or control points) by category, and the bounds that define the extent those thresholds are applied. Control parameters for the risk management effort include the level of control for risks, the approval levels for implementing mitigation and accepting the results of that mitigation, risk reassessment intervals, and rules used to consolidate risks.

[PA148.IG101.SP102.N101]

Typical Work Products

1. Risk evaluation, classification, 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 bands on the likelihood and severity levels) allows the impacts of different risks to be commonly understood, receive the appropriate level of scrutiny, and 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 (or control points) can be established to determine acceptability or unacceptability of risks, prioritization of risks, or triggers for management action. For example, project wide thresholds could be established such as when product costs exceed 10% of the target cost. 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 mitigation plans. [PA148.IG101.SP102.SubP102.N101]

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 what 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, for example, not including asteroids under environment risks. These bounds may also exclude any condition that occurs less than a given frequency, for example, exclude any events that have a likelihood of occurrence of less than 10% over the expected lifetime of the product. [PA148.IG101.SP102.SubP103.N101]

SP 1.3 Establish a Risk Management Strategy

Establish and maintain the strategy and methods 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 used to bound 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, classified, bounded and consolidated
- Global thresholds, parameters and criteria for taking action on identified risks

- Risk mitigation techniques to be used, such as prototyping, simulation, alternative designs, or evolutionary development
- Responsibilities such as control or approval levels
- 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. [PA148.IG101.SP103.N102]

The risk management strategy is often captured in a project risk management plan. The risk management strategy is reviewed with relevant stakeholders in order to promote commitment and understanding. [PA148.IG101.SP103.N103]

Typical Work Products

1. Project risk management plan [PA148.IG101.SP103.W101]

SG 2 Identify and Analyze Risks [PA148.IG102]

Risks are identified and analyzed to determine their relative importance.

The degree of risk impacts the resources assigned to handle an identified risk and in determining when appropriate management attention is required. [PA148.IG102.N101]

Analyzing risks entails the identification of risks from the internal and external sources identified and then evaluating each identified risk to determine its likelihood and consequences. Classification 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 need to be considered. For example, risks associated with loss of inter-team or intra-team coordination. *[PA148.IG102.SP101.AMP101]*

The identification of potential issues, hazards, threats, vulnerabilities, etc., 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 re-examine possible sources of risk and changing conditions to uncover sources and risks previously overlooked or non-existent 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 during development. 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 product validation.

[PA148.IG102.SP101.SubP101.N101]

In addition to the cost risks identified above, development cost risks can include those associated with funding levels, funding estimates, and distributed budget.

[PA148.IG102.SP101.SubP101.N102]

Development schedule risks can include those 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
- Performance maintenance attributes

Performance maintenance attributes are those characteristics that enable an in-use product to provide originally required performance, for example, maintaining safety and security performance. [PA148.IG102.SP101.SubP101.N105]

There are other risks that do not fall "neatly" into cost, schedule, or performance categories. [PA148.IG102.SP101.SubP101.N106]

Examples of these 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, telecommunications failures, etc. [PA148.IG102.SP101.SubP102.N101]

3. Review all elements of the work breakdown structure as part of the risk identification process in order 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 the risk identification process in order 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 captured 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 affected parties associated with each risk. [PA148.IG102.SP101.SubP106]

SP 2.2 Evaluate, Classify, and Prioritize Risks

Evaluate and classify each identified risk using the defined risk categories and parameters, and determine its relative priority.

[PA148.IG102.SP102]

The rating of risks is needed to assign relative importance to each identified risk, to be used in determining when appropriate management attention is required. Often it is useful to aggregate risks based on their inter-relationships, 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 assure that important lower-level risks are not ignored. [PA148.IG102.SP102.N101]

Risks are quantified using parameters such as likelihood (probability), and consequence (impact), but may also include additional parameters. A combination of these rated values is typically used to determine overall priority for risk handling. [PA148.IG102.SP102.N102]

Collectively, the activities of risk evaluation, classification, and prioritization are sometimes called risk assessment or risk analysis. [PA148.IG102.SP102.N103]

Typical Work Products

1. List of risks, with a rating of parameter values for 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 evaluation parameters, which may include likelihood, consequence (severity, or impact), and timeframe. 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 rate 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: [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 ratings. In addition, ratings may require reevaluation as time progresses. [PA148.IG102.SP102.SubP101.N103]

2. Classify and group risks according to the defined risk categories. [PA148.IG102.SP102.SubP102]

Risks are classified 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 captured. [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 apply resources for mitigation of risks with the greatest impact to the project. [PA148.IG102.SP102.SubP103.N101]

SG 3 Mitigate Risks [PA148.IG103]

Risks are handled and mitigated, where appropriate, to reduce adverse impacts on achieving objectives.

The steps in handling risks include developing risk-handling options, monitoring risks, and performing risk-handling activities when defined thresholds are exceeded. 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 criteria, thresholds, and 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 risk mitigation plan determines the levels and thresholds that define when an identified risk becomes unacceptable, and triggers risk-handling activity. Mitigation plans are often generated only for selected risks of high consequence; other risks may be accepted and simply monitored. [PA148.IG103.SP101.N101]

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 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. These mitigation plans are deployed upon exceeding the established thresholds in order to return the impacted effort to an acceptable risk level. The risk management strategy defines the criteria, thresholds and parameters to be used in determining when risk-handling actions are necessary. [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 monitor: Watching and periodically reevaluating the risk for changes to the assigned risk parameters
- Risk acceptance: Acknowledgment of risk but deciding not to take 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. Mitigation plans [PA148.IG103.SP101.W102]
3. 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 risk-handling activity.

[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 (or control points) that bound planned or acceptable performance need to be clearly understood and defined to provide a means with which risk can be understood. Proper classification of risk is essential for ensuring both appropriate priority based on severity and the associated management response. There may be multiple thresholds (or control points) employed to initiate varying levels of management response.

[PA148.IG103.SP101.SubP101.N102]

2. Identify the person or group responsible for addressing each risk.

[PA148.IG103.SP101.SubP102]

3. Determine the cost-benefit of implementing the mitigation plan for each risk. [PA148.IG103.SP101.SubP103]

Risk mitigation activities should be examined for the benefits they provide versus the resources to be expended. Just like any other design activity, alternative plans may need to be developed and the cost-benefits assessed. The most appropriate plan is then selected for implementation. At times, the risk is significant and the benefits small, but the risk must be mitigated (unacceptable consequences). [PA148.IG103.SP101.SubP103.N101]

4. Develop an overall mitigation plan for the project to orchestrate the implementation plan for each risk. [PA148.IG103.SP101.SubP104]

The complete set of risk mitigation plans may not be affordable. A tradeoff analysis should be performed to prioritize the 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 are realized into problems that impact the project. Contingency plans may 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 (mitigation) or respond (contingency) to a risk, but in either event as a managed risk.

[PA148.IG103.SP101.SubP105.N101]

Some risk management literature may consider contingency plans a synonym or subset of mitigation plans. They also may be addressed together termed 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 through the duration of the work effort, follow a proactive program to regularly monitor risks and the status and results of the 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 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, ratings, 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. 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. [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 plan or 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 strategy. [PA148.IG103.SP102.SubP105]

6. Collect performance metrics 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 requirements and objectives, and plans for performing the risk management process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are described in the plan for risk management. This plan for risk management differs from the risk management strategy described in the specific practice in this process area. The risk management strategy addresses risk sources, categories, parameters, and management control and reporting requirements; whereas the plan for risk management addresses high level planning for all the risk management 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 tools used in performing the activities of the Risk Management process area include the following: [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 practices (e.g., risk identification, evaluation, monitoring, mitigation)
- Metric 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: [PA148.EL120]

- Establishing a collaborative environment for free and open discussion of risk
- Reviewing the risk strategy and risk management plan
- 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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Risk Management process area 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 management plan (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]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the risk management process and the work products and services of the process to the applicable requirements, objectives, and standards, 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, this 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 life cycle
- collaborate internally among themselves and externally with other teams and stakeholders as appropriate
- share a common understanding of the team's tasks and objectives.

An integrated team (also known as an Integrated Product Team or IPT) is composed of 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. 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 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 during product development.
- 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 be representing 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 is focused 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 organizational shared vision. *[PA170.R102]*

Refer to the Integrated Project Management (IPPD) process area for more information about coordinating and collaborating with stakeholders, establishing the team structure, and considering IPPD organizational process assets. *[PA170.R103]*

Specific and Generic Goals

SG 1 **Establish Team Composition** [PA170.IG101]

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

- 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 [PA170.IG101]

Team composition that provides the knowledge and skills required to deliver the team's product is established and maintained.

Because 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 life-cycle decisions for the work product being acquired and developed. Team member selection and skill mix should be based on its product-focused and life cycle objectives and, therefore, 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]

Refer to the Establish Project Tasks and Responsibilities specific practice in the Project Planning process area to see how this is done at the project level. *[PA170.IG101.SP101.N101.R101]*

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 efforts of the entire team, but review and judgment is a team responsibility. [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 with respect to a work breakdown hierarchy. *[PA170.IG101.SP102.R101]*

The functional knowledge and related job skills within the integrated team are directly related to the specific team tasks and responsibilities. A fully effective integrated team is able to perform to all its tasks and is comprised of all the necessary technical and business specialties, expertise, and advocates to ensure 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 or processes that the integrated team must maintain competence in to perform to its objectives. [PA170.IG101.SP102.SubP101]
2. Identify the core competencies on which to base the integrated team's activities in order to sustain or achieve desired capability. [PA170.IG101.SP102.SubP102]
3. Establish knowledge and skills 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 compliment 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 work load 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 leadership/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 the team operation and product development process 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. [PA170.IG101.SP103.SubP104.N101]

SG 2 Govern Team Operation [PA170.IG102]

Operation of the integrated team is governed according to established principles.

13853 An integrated team operates in a disciplined way that brings about
13854 effectiveness and productivity in meeting its objectives. Established
13855 principles and operating practices help both the team leader and team
13856 members to manage group dynamics and to ensure successful
13857 interplay among the multiple functions within the team. [PA170.IG102.N101]

13858 ### SP 2.1 Establish a Shared Vision

13859 ***Establish and maintain a shared vision for the integrated team that***
13860 ***is aligned with any overarching or higher-level vision.***
13861 *[PA170.IG102.SP101]*

13862 *Refer to the Provide IPPD Infrastructure specific goal in the*
13863 *Organizational Environment for Integration process area for more*
13864 *information on the organization's shared vision.* *[PA170.IG102.SP101.R101]*

13865 *Refer to the Use the Project's Shared Vision specific goal in the*
13866 *Integrated Project Management (IPPD) process area for more*
13867 *information about the project's shared vision.* *[PA170.IG102.SP101.R102]*

13868 The purpose of a shared vision is to provide a statement of an
13869 envisioned future and establish common understanding of the
13870 aspirations and governing ideals of the team in the context of that
13871 desired end state. The shared vision anchors the team's governing
13872 ideas and principles and captures the objectives to be achieved. The
13873 shared vision guides the activities of the team and helps drive the team
13874 to achieve their mission and objectives. A shared vision facilitates
13875 working together and helps to attain unity of purpose among team
13876 members. [PA170.IG102.SP101.N101]

13877 No team operates in isolation and a shared vision for the integrated
13878 team is critical to ensure the team's charter, direction, and activities
13879 achieve a fit with any larger project objectives or other interfacing
13880 teams. A team's sponsor(s) or leader may establish the vision for the
13881 organization or a project for which the integrated team is a part. An
13882 integrated team's shared vision, if developed on their own, must be
13883 aligned with and support achievement of the project's and
13884 organization's higher-level objectives as well as its own. When one
13885 team falls short of or strays from of its objectives and vision, it is likely to
13886 cause significant impact to the overall success of the project.
13887 [PA170.IG102.SP101.N102]

Shared vision context has both an external and internal aspect. The external aspect has to do with the overlying plan, 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 (shared), 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. Documented stakeholder exceptions and conclusions [PA170.IG102.SP101.W101]
2. Boundary conditions and interfaces within which the team must operate. [PA170.IG102.SP101.W102]
3. Documented vision statement [PA170.IG102.SP101.W103]
4. Presentation material of the 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 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 present reality 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 the sponsor of the team 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 process between the sponsor of team and the integrated team. When approved by both the team and the sponsor, the team charter constitutes a recognized agreement with the 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 metrics 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 decision and actions has been properly delegated from upper management. The team decides whether the decision-making authority is appropriate to meet expectations and 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 the 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 accomplishment 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' contribution, level of involvement, interfaces (to 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]

- Interfaces among integrated team members
- How assignments are accepted
- How resources and input are accessed
- How work gets done
- Who checks and reviews work
- How work is approved
- How work is delivered and communicated

- Maintaining 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 practices and ground rules serve to define and control how the team will interact and work together and 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 practices 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 together 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 in 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 in 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 (IPPD) process area for more information about operating in an integrated environment, and about coordinating and collaborating with 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 for the team's life cycle [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 (IPPD) process area for more information about coordinating and collaborating with stakeholders. *[PA170.IG102.SP105.SubP102.R101]*

3. Collaboratively develop, communicate, and distribute among interfacing teams commitment lists and work plans 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 requirements and objectives, and plans for performing the integrated teaming process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are described in the organization's plan for integrated teaming. [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 tools used in performing the activities of the Integrated Teaming process area include the following: [PA170.EL104]

- Interactive electronic communication and 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: [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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Integrated Teaming process area include the following: [PA170.EL108]

- Performance to and deviations from expected plans, commitments, and procedures for the integrated team
- 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 and the work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA170.EL109]

- Defining 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 make decisions using a structured approach that evaluates identified alternatives against established criteria. [PA156]

Introductory Notes

Decision Analysis and Resolution involves making good decisions by (1) selecting a decision-making technique and level of structure, (2) identifying criteria that will be the basis of the decision, (3) identifying alternatives, and (4) evaluating the alternatives against the criteria. [PA156.N101]

A structured decision-making process reduces the subjective nature of the decision and has a higher probability of selecting a solution that meets the multiple demands of the stakeholder community. [PA156.N102]

While the primary application of a structured decision-making process is technical concerns, the decision analysis and resolution processes also applicable to many non-technical issues. Issues that have multiple alternative solutions and evaluation criteria lend themselves to structured decision-making. Binary decisions are not as appropriate. [PA156.N103]

Trade studies of equipment or software are typical examples of structured decision-making. [PA156.N111]

During project planning, project staff identify which specific issues will require a structured decision-making process. 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 issues. In production, project staff can use the Decision Analysis and Resolution process area to address a make-or-buy decision, the development of manufacturing processes, the selection of distribution locations, and other decisions. [PA156.N104]

Project planning activities also frequently involve non-technical issues that would benefit from structured decision analysis. [PA156.N105]

During project planning, guidelines are also created for deciding when to use a structured decision-making process to address unplanned issues. Guidelines often suggest using a structured decision-making process when issues are associated with medium to high risks or when issues affect the ability to achieve project objectives. [PA156.N106]

A structured decision-making process can vary in its formality, type of criteria, and technique. Less formal decisions can be performed 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 person-hours, 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 structured decision-making 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 structured decision-making process identifies and evaluates alternative solutions. The eventual selection of a final 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 final selection of an alternative is accompanied by documentation of the selected technique, criteria, and alternatives; and the rationale for the selection of the final solution. The documentation is distributed to the stakeholders; it provides a record of the decision 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. The Project Planning process area determines the issues that undergo a structured decision-making process and develops guidelines for deciding when to apply a structure decision-making process to unforeseen issues. [PA156.R101]

Refer to the Integrated Project Management (IPPD) process area for more information about establishing the project's defined process. The project's defined process includes a structured decision-making process for each selected issue and incorporates the use of guidelines for applying a structured decision-making process to unforeseen issues. [PA156.R102]

Refer to the Risk Management process area for more information about identifying and mitigating risks. A structured decision-making process often addresses issues with identified risks. Selected solutions typically impact risk mitigation strategies. *[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 and Use Guidelines for Decision Analysis
SP 1.2	Select Decision-Making Techniques
SP 1.3	Establish Evaluation Criteria
SP 1.4	Identify Alternative Solutions
SP 1.5	Evaluate Alternatives
SP 1.6	Select Solutions

GG 3 Institutionalize a Defined Process

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** [PA156.IG101]

Decisions are based on an evaluation of alternatives using established criteria.

Issues requiring a decision-making 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 and Use Guidelines for Decision Analysis

Establish and use guidelines to determine which issues are subject to a structured decision analysis and resolution process. *[PA156.IG101.SP101]*

Refer to the Project Planning process area for more information about planning which issues will undergo a structured decision-making process. *[PA156.IG101.SP101.R101]*

Refer to the Risk Management process area for more information about determining which topics are medium or high risk. *[PA156.IG101.SP101.R102]*

Most decisions do not require structured decision making, but somewhere between the trivial and the clearly important, the choice may be unclear without explicit criteria. Whether an issue 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 structured decision-making 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 percent or specific amount of time
- When a decision affects the ability to achieve project objectives
- When the costs of the decision process are reasonable when compared to the decision's impact

Examples of when to use structured decision-making 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 structured decision-making [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 (IPPD) process area for more information about establishing the project's defined process. *[PA156.IG101.SP101.SubP102.R101]*

SP 1.2 Select Decision-Making Techniques

Select the decision-making techniques. *[PA156.IG101.SP102]*

Decision-making techniques, ranging from consensus-based decisions to the use of probabilistic models and decision theory, should be considered and selected appropriately. The level of detail of a study should be commensurate with cost, schedule, performance, and risk impacts. [PA156.IG101.SP102.N101]

While many problems may need only one decision-making technique, some problems may require multiple techniques. 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 decision-making techniques [PA156.IG101.SP102.W101]

Subpractices

1. Select the techniques based on the purpose for making a decision and on the availability of the information used to support the technique. [PA156.IG101.SP102.SubP101]

   For example, the appropriate technique for selecting a preferred approach when requirements are weakly defined may be different than the technique used when the requirements are well defined. [PA156.IG101.SP102.SubP101.N101]

   Typical decision-making techniques include: [PA156.IG101.SP102.SubP101.N102]

   - Trade studies
   - Probabilistic models
   - Delphi method
   - Quality function deployment
   - Group techniques

2. Select techniques 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 level of structure of the decision-making process. [PA156.IG101.SP102.SubP103]

   Consider the impact on cost, schedule, performance, and existing risk strategies. [PA156.IG101.SP102.SubP103.N101]

SP 1.3 Establish Evaluation Criteria

Establish the evaluation criteria and their relative ranking.

[PA156.IG101.SP103]

The evaluation criteria provide the basis for the rest of the decision-making process. These criteria must reflect the various stakeholder needs and objectives. The criteria are ranked so that the highest ranked criteria exert the most influence on the decision. [PA156.IG101.SP103.N101]

Document evaluation criteria to alleviate the possibility of second-guessing decisions, or simply forgetting why decisions were made. 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. Develop evaluation criteria and their validity. [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: [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 stakeholders. [PA156.IG101.SP103.SubP103.N101]

4. 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]

5. Test the criteria and their relative importance. [PA156.IG101.SP103.SubP105]

   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. This test allows the cumulative impact of a set of criteria on the solution to be evaluated. In such cases, the alternatives may be different than the proposed alternatives, to avoid biases. [PA156.IG101.SP103.SubP105.N101]

SP 1.4 Identify Alternative Solutions

Identify alternative solutions to issues. *[PA156.IG101.SP104]*

A wider range of alternatives can surface by soliciting as many stakeholders as practical for input. Inputs from stakeholders with diverse skills and backgrounds can help 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-making 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 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 stakeholders and staff. 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 1.5 Evaluate Alternatives

Evaluate alternative solutions using the documented criteria.

[PA156.IG101.SP105]

Evaluating alternative solutions involves synthesizing 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 these cases, the best selection among alternative solutions may not be clear-cut when the resulting scores differ by relatively small amounts. Challenges to criteria and assumptions should be encouraged. [PA156.IG101.SP105.N102]

Typical Work Products

1. Evaluation results [PA156.IG101.SP105.W101]
2. Documented evaluation results [PA156.IG101.SP105.W102]

Subpractices

1. Evaluate the proposed alternative solutions using the documented evaluation criteria. [PA156.IG101.SP105.SubP101]
2. Evaluate the assumptions related to the selection 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 test the selection criteria. [PA156.IG101.SP105.SubP104]
5. Consider new alternative solutions if the proposed alternatives do not 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 studies 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 the solutions or execution of the structured decision-making process must be assessed. The final selection of the solutions is contingent upon the approval of the stakeholder community. [PA156.IG101.SP106.N101]

Typical Work Products

1. Solutions to significant problems or issues [PA156.IG101.SP106.W101]

Subpractices

1. Assess the risks associated with making a decision.
   [PA156.IG101.SP106.SubP101]

   Refer to the Risk Management process area for more information about how to follow up on risks. *[PA156.IG101.SP106.SubP101.R101]*

   Decisions must often be made with incomplete information. There can be substantial risk associated with the decision as a result 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-evaluation at a later time. Identified risks should be monitored. [PA156.IG101.SP106.SubP101.N102]

2. Document the results and rationale of the decision.
   [PA156.IG101.SP106.SubP102]

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 making decisions using a structured approach that evaluates identified alternatives against established criteria. The policy should also provide guidance on which decisions require a structured decision-making approach.
[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 requirements and objectives, and plans 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]*

Elaboration:

Examples of tools used to perform the activities of the Decision Analysis and Resolution process area include the following: [PA156.EL102]

- Simulators and modeling tools
- Prototyping tools
- Support tools for group decision-making

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
- Decision-making techniques (e.g., trade studies, Delphi methods, quality function deployment, group decision-making techniques)

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 structured decision-making
- Evaluation report

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: [PA156.EL109]

- Establishing guidelines for which issues are subject to a structured decision analysis and resolution process
- Developing evaluation criteria
- Identifying and evaluating alternatives
- Selecting a solution

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the decision analysis and resolution process against the plan and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the decision analysis and resolution process area include the following: [PA156.EL105]

- Cost to benefit ratio of an instance of the Decision and 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA156.EL106]

- Evaluating alternatives

Examples of work products reviewed include the following: [PA156.EL108]

- Guidelines for when to apply structured decision-making
- Evaluation report

14612 ## GP 2.10 (VE 2) Review Status with Higher-Level Management

14613 ***Review the activities, status, and results of the decision analysis***
14614 ***and resolution process with higher-level management and resolve***
14615 ***issues.*** *[GP112]*

ORGANIZATIONAL ENVIRONMENT FOR INTEGRATION

Maturity Level 3

Purpose

The purpose of Organizational Environment for Integration is to provide an 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 organizational standard processes and 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 (IPPD) process area for more information about managing stakeholder involvement, resolving coordination issues, establishing the project's shared vision, and organizing integrated teams. [PA169.R101]

Refer to the Organizational Process Definition process area for more information about establishing the organization's set of standard processes and library of process assets. [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 effects 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]

- SP 1.1 Establish the Organization's Shared Vision
- SP 1.2 Establish an Integrated Work Environment
- SP 1.3 Identify IPPD-Unique Skill Requirements

SG 2 Manage People for Integration [PA169.IG102]

- SP 2.1 Establish Leadership Mechanisms
- SP 2.2 Establish Incentives for Integration
- SP 2.3 Establish Mechanisms to Balance Team and Home Organization Responsibilities

GG 3 Institutionalize a Defined Process

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 Provide IPPD Infrastructure [PA169.IG101]

An infrastructure that maximizes the productivity of people and effects the collaboration necessary for integration is provided.

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: [PA169.IG101.N101]

- An organization 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. A shared vision captures the organization's guiding principles including mission, objectives, expected behavior, and values. The shared vision 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. [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 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 vision broad statements about integrated teaming and employee empowerment. It is more important, however to use the vision to set reasonable expectations on the rate of change in an organization. Unrealistic proclamations can transform the vision into a source of frustration and cause the organization to retreat from it after initial pilot demonstrations. [PA169.IG101.SP101.N104]

The shared vision should be articulated in sufficient detail to provide criteria against which the project and integrated teams' shared visions 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 project and integrated team shared visions. 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 project, integrated team, and people expectations 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 vision to determine weaknesses and misunderstood parts. Revise the vision to improve its clarity and applicability to the present reality of the organization. Periodically reinforce the clarity and reality of the 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 project and integrated team shared visions. [PA169.IG101.SP101.SubP106.N101]

   Project visions should be focused on product and contribute to the organizational vision achievement. Project visions 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 project visions are tested against the organizational 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 effect integrated teamwork throughout the life cycle. 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 the information sharing. This can improve effectiveness, especially early in the product life cycle. Appropriate mechanisms might include meeting rooms, email, fax, ftp or Web sites, video teleconferencing capabilities and others depending on the organization's culture and 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 wasted time spent converting information from one medium or platform to another, and correcting transcription or misunderstandings when people do the conversions. Requirements for product and process information usability across the product life cycle 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 on-going 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, and benchmarking. [PA169.IG101.SP102.SubP103.N101]

   Examples of technologies, tools, and resources include: [PA169.IG101.SP102.SubP103.N102]

   - Computing resources and software productivity tools
   - Communications systems, tools, and resources
   - Communication tools (e-mail, 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
- "Hot-lines" 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 maintenance of the environment) and risks (for example, work flow and project disruptions)? Requirements are developed for the life cycle of the work environment and address, as appropriate, the three different cases for work environment improvements: development of 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 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 life cycle 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 experienced 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: [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 needs to 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 capabilities, 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 not only the differences between disparate functions and disciplines, but also the differences in cultures, values, and backgrounds. [PA169.IG101.SP103.N104]

The leadership demands also increase under IPPD. Leadership challenges include: ensuring all team members mutually understand their roles and responsibilities; employing people in their intended roles; and effectively accessing and integrating the depth and wealth of specific expertise resident in the organization 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 to the organization's strategic training plan. [PA169.IG101.SP103.SubP101]
2. Provide requirements for IPPD skills to the organization's tactical training plan. [PA169.IG101.SP103.SubP102]
3. Ensure that IPPD skills are being provided. [PA169.IG101.SP103.SubP103]

SG 2 Manage People for Integration [PA169.IG102]

People are managed to nurture the integrative and collaborative behaviors of an IPPD environment.

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 effect integrated teamwork throughout the life cycle. The organization establishes the IPPD guidelines and processes that become part of the organization's process assets 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 tool 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 process assets. [PA169.IG102.N102]

SP 2.1 Establish Leadership Mechanisms

Establish and maintain leadership mechanisms to enable timely collaboration. *[PA169.IG102.SP101]*

Implementation of IPPD introduces challenges to leadership practices because of the cultural changes required when people and integrated teams are empowered and decisions are driven to the lowest level appropriate. The effectiveness and efficiency of communications mechanisms in the integrated work environment are critical to timely and sound decision-making. 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 effect 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 needs to occur at the lowest level or needs to be done collaboratively or even 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 are: [PA169.IG102.SP101.N104]

- Command The leader examines the issue and make 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 of the stakeholders, including the leader, the issues are discussed, and solutions voted upon. Rules are needed to determine whether this vote is binding on the leader.
- Consensus -- Issues are raised by any of the stakeholders, including the leader, and discussed until all members of the integrated team can live with and support the decision.
- Structured A major issue to be decided by structured decision making. The steps in structured decision making may be carried out in a collaborative way.

For many issues, the command decision type may be adequate. For issues that require several different areas of expertise or that have far-reaching consequences, the 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, and that 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 area of expertise. This flexibility can result in improved group efficiency and effectiveness. [PA169.IG102.SP101.N107]

15042 Even with well-intentioned empowerment, leadership, and decision-
15043 making, issues will arise that cannot be resolved at the same level. An
15044 organizational process for issue resolution can form the basis for
15045 project- and integrated team-specific procedures and help ensure that
15046 basic issue resolution avenues are available to projects and integrated
15047 teams when unresolved issues need to be escalated. An organizational
15048 process for issue resolution can serve both issue resolution and issue
15049 prevention roles. [PA169.IG102.SP101.N108]

15050 **Typical Work Products**

15051 1. Guidelines for determining the degree of empowerment of people
15052 and integrated teams [PA169.IG102.SP101.W101]

15053 2. Guidelines for setting leadership and decision-making context
15054 [PA169.IG102.SP101.W102]

15055 3. Organizational process documentation for issue resolution
15056 [PA169.IG102.SP101.W103]

15057 **Subpractices**

15058 1. Establish and maintain guidelines for the degree of empowerment
15059 provided to people and integrated teams. [PA169.IG102.SP101.SubP101]

15060 2. Collaboratively determine rules for the use of different decision
15061 types in making various kinds of decisions. [PA169.IG102.SP101.SubP102]

15062 *Refer to the Decision Analysis and Resolution process area for more*
15063 *information about structured decision making and evaluating and*
15064 *selecting among alternatives. [PA169.IG102.SP101.SubP102.R101]*

15065 3. Define the process for using the decision-making rules.
15066 [PA169.IG102.SP101.SubP103]

15067 4. Define a process for conflict resolution when an issue cannot be
15068 decided at the level at which it arose. [PA169.IG102.SP101.SubP104]

15069 ## SP 2.2 Establish Incentives for Integration

15070 ***Establish and maintain incentives for adopting and demonstrating***
15071 ***integrative and collaborative behaviors at all levels of the***
15072 ***organization.*** *[PA169.IG102.SP102]*

15073 The recognition and reward systems in an organization are one of the
15074 motivators for behavior and value changes. To support IPPD, the
15075 recognition and reward systems (both positive rewards and negative
15076 consequences) need to recognize a shift in values from single point of
15077 success or failure (e.g., providing a management incentive package to
15078 the product or program manager alone) to integrated team success or
15079 failure (e.g., providing layered incentives to integrated team members
15080 based on degree of involvement and contribution). [PA169.IG102.SP102.N101]

Individual excellence still needs to be recognized, but criteria should discern whether such excellence was achieved at the expense of the integrative behaviors expected or in support of it. 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 need to 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 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 the giving of 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 and such immediate recognition reinforces the collaborative nature of working in an IPPD environment. If staff have to 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 need to 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. Compensation policies and procedures [PA169.IG102.SP102.W101]
2. Integrated team and individual recognition and rewards [PA169.IG102.SP102.W102]

Subpractices

1. Structure the recognition and reward process to be consistent with the IPPD environment. [PA169.IG102.SP102.SubP101]

   The organization's recognition and reward process 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 recognition as well as individual. [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 need to recognize that people's responsibility is focused on the integrated team, not to the traditional home organization. A balance must be struck, however, because the responsibility of integrated team members to their respective home organizations are still important, specifically for process implementation and improvement. Workloads should be balanced between projects and functions, while ensuring career growth and advancement. Mechanisms need to 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 requirements and objectives, and plans for performing the organizational environment for integration process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are described in the organization's plan for the organizational environment for integration. [PA169.EL102]

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: [PA169.EL103]

- Manufacturing and production facilities
- Prototyping or production equipment
- Work space
- Office equipment and supplies
- Raw or stock input materials
- Transportation resources
- "Hot-lines" and "help-desks"
- Information brokerage services
- Support staff and/or services

Examples of tools used in performing the activities of the Organizational Environment for Integration process area include the following: [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: [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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Organizational Environment for Integration process area 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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 for issues

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

Refer to the Model Components section of the Structure of the Model chapter of the Overview for more information about CMMI maturity levels. *[FM111.T101.R101]*

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, 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 efficiency) 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 summarize the actual performance of processes in individual projects in the organization. The organizational data for these measures is 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 organization's process assets. [PA164.N103]

The associated process capability models are used to represent past and current process performance and to predict future results of the process. [PA164.N104]

For example, the latent defects in the delivered product can be predicted using measurements of defects identified during the product verification activities. [PA164.N107]

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 that perform within consistent natural bounds 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 implementations of processes which may be best practices.

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, 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

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 [PA164.IG101]

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

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 organization’s process assets.
[PA164.IG101.SP101.R101]

The organization's set of standard processes consists of a set of standard processes that, in turn, are comprised of process elements.
[PA164.IG101.SP101.N101]

15412 Typically, it will not be possible, useful, or economically justifiable to
15413 apply quantitative process performance techniques to all processes or
15414 process elements of the organization's set of standard processes.
15415 Selection of the processes and/or process elements is based upon the
15416 needs and objectives of both the organization and projects.
15417 [PA164.IG101.SP101.N102]

15418 **Typical Work Products**

15419 1. List of process or process elements identified for process
15420 performance analyses [PA164.IG101.SP101.W101]

15421 ## SP 1.2 Establish Process Performance Measures

15422 ***Establish and maintain definitions of the measures that are to be***
15423 ***included in the organization's process performance analyses.***
15424 *[PA164.IG101.SP102]*

15425 *Refer to the Measurement and Analysis process area for more*
15426 *information about selecting measures.* *[PA164.IG101.SP102.R101]*

15427 **Typical Work Products**

15428 1. Definitions for the selected measures of process performance
15429 [PA164.IG101.SP102.W101]

15430 **Subpractices**

15431 1. Determine which of the organization's business objectives for
15432 process performance need to be addressed by the measures.
15433 [PA164.IG101.SP102.SubP101]

15434 2. Select measures that provide appropriate insight into the
15435 organization's process performance. [PA164.IG101.SP102.SubP102]

15436 The Goal Question Metric paradigm is an approach that can be used to select
15437 measures that provide insight into the organization’s business objectives.
15438 [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 of the entire life cycle
- 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 common set of measures. [PA164.IG101.SP102.SubP103]

Refer to the Organizational Process Definition process area for more information about establishing the organization's 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 process performance objectives have the following characteristics: [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, and cycle time for product development

Typical Work Products

1. Organization's process performance objectives [PA164.IG101.SP103.W101]

Subpractices

1. Review the organization's business objectives related to 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 time for a specified release of a product.
- Decrease the cost of maintenance of the products currently in development by a specified percent.

2. Define the organization's quantitative objectives for process performance. [PA164.IG101.SP103.SubP102]

   Objectives may be established for both process measurements (e.g., effort, cycle time, and defect removal efficiency) and product measurements (e.g., reliability and defect density). [PA164.IG101.SP103.SubP102.N101]

Examples of 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 process performance. [PA164.IG101.SP103.SubP103]
4. Review, negotiate, and obtain commitment for the organization's process performance objectives and their priorities from the relevant stakeholders. [PA164.IG101.SP103.SubP104]
5. Revise the organization's quantitative objectives for process performance as necessary. [PA164.IG101.SP103.SubP105]

Examples of when the organization's quantitative objectives for 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 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 measure 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]

15508 - Individual process elements (e.g., test case inspection element)
15509 - Sequence of connected processes
15510 - Processes for the complete life cycle
15511 - Processes for developing individual work products

15512 There may be several process performance baselines to characterize
15513 performance for subgroups of the organization. [PA164.IG101.SP104.N102]

15514 Examples of criteria used to categorize subgroups include the following:
15515 [PA164.IG101.SP104.N104]

15516 - Product line
15517 - Application domain
15518 - Complexity
15519 - Team size
15520 - Work product size
15521 - Process elements from the organization's set of standard
15522 processes

15523

15524 Allowable tailoring of the organization’s set of standard processes may
15525 significantly affect the comparability of the data for inclusion in process
15526 performance baselines. The effects of tailoring should be considered in
15527 establishing baselines. [PA164.IG101.SP104.N103]

15528 *Refer to the Quantitative Project Management process area for more*
15529 *information about the use of process baselines [PA164.IG101.SP104.N103.R101]*

15530 **Typical Work Products**

15531 1. Baseline data on the organization’s process performance
15532 [PA164.IG101.SP104.W101]

15533 **Subpractices**

15534 1. Collect measurements from the organization’s projects.
15535 [PA164.IG101.SP104.SubP101]

15536 *Refer to the Measurement and Analysis process area for information*
15537 *about collecting and analyzing data [PA164.IG101.SP104.SubP101.R101]*

15538 2. Establish and maintain the organization's process performance
15539 baselines from the collected measurements and analyses.
15540 [PA164.IG101.SP104.SubP102]

15541 *Refer to the Measurement and Analysis process area for information*
15542 *about measuring process performance to establish performance*
15543 *baselines. [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 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 cycle to estimate progress toward achieving objectives which cannot be measured until later in the life cycle. [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 to use models include the following: [PA164.IG101.SP105.N104]

- Schedule and cost
- Reliability
- Defect identification and removal rates
- Defect removal efficiency
- Latent defect estimation
- Development progress
- A combination 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 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]

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 requirements and objectives, and plans 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]*

Elaboration:

Special expertise in statistics and statistical process control may be needed to establish the performance baseline of the organization's set of standard processes. [PA164.EL111]

Examples of tools used in performing the activities of the Organizational Process Performance process area include the following: [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]

- Organizational 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: [PA164.EL112]

- Establishing the organization’s 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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Organizational Process Performance process area 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 and the work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance. *[GP113]*

Elaboration:

Examples of activities reviewed include the following: [PA164.EL106]

- Establishing performance baselines and models

Examples of work products reviewed include the following: [PA164.EL110]

- Process performance plans
- Organizational process performance objectives
- Definition for the selected measures of process performance

15734 **GP 2.10 (VE 2) Review Status with Higher-Level Management**

15735 ***Review the activities, status, and results of the organizational***
15736 ***process performance process with higher-level management and***
15737 ***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

Quantitative Project Management 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 and/or models
- Selecting the subprocesses of the project's defined process to be statistically managed
- Selecting the measures and analytic techniques to be used in statistically managing the selected subprocesses
- Establishing and maintaining statistical control of the selected subprocesses using the selected measures and analytic techniques
- Determining whether the selected subprocesses are capable of satisfying their quality and process performance objectives, and taking corrective action as necessary
- Determining whether the project's defined process is able to satisfy the project's objectives, and take corrective action when appropriate
- Recording statistical and quality management data in the organization's measurement repository

The process performance objectives, measures, and baselines identified above are developed through the Organizational Process Performance process area. Subsequently, the results of performing the Quantitative Project Management process area (measurement definitions, measurement data etc.) are part of the organizational assets referred to in the Organizational Process Performance process area. [PA165.N102]

Prior to implementing this process area, the organization should have already established a set of standard processes and related process assets such as the organization's measurement repository and the 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 from the organization's set of standard processes. [PA165.N103]

The organization's measurement repository and process asset library provide information that assist in composing a defined process that will achieve the objectives that have been established by the project. [PA165.N104]

In this process area, the phrase "quality and process performance objectives" covers objectives and requirements for product quality, service quality, and process performance. As commonly used, 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." [PA165.N105]

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 finer-grained process descriptions. [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. [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 achieving the project's quality and process performance objectives. This recognition is a basis for taking corrective action. [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 take corrective action when appropriate. [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

In this process area, the term "product" refers to products or services or both, as appropriate. [PA165.N112]

Related Process Areas

Refer to the Project Monitoring and Control process area for more information about monitoring and controlling project progress and performance. *[PA165.R101]*

Refer to 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 objective 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 (IPPD) 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 to be 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

- 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 [PA165.IG101]

The project is quantitatively managed using quality and process performance objectives.

SP 1.1 Establish the Project's Objectives

Establish and maintain the project's quality and process performance objectives. *[PA165.IG101.SP101]*

This specific practice is typically performed early during project planning. [PA165.IG101.SP101.N101]

Note that the first three specific practices for Goal 1 of this process area may be addressed concurrently. When establishing the project's quality and process performance objectives, it is often useful to think ahead about which elements of the organization standard set of processes will be included in the projects defined process. Also, it is important to identify what subprocesses need to be statistically managed in order for the project to achieve those objectives The balance between project quality and performance objectives and the estimated performance of the projects defined process is typically developed through multiple iterations. Initially, project performance objectives are set. Then, the expected performance of the projects defined process is identified. If there is a difference between project quality and performance objectives and the defined project process performance estimate, negotiations between relevant stakeholders are required to eliminate the difference. [PA165.IG101.SP101.N102]

Typical Work Products

1. The project's documented 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 the project understands the broader business context in which the project will need to operate. The project's objectives for quality and process performance will be 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
- Development cycle time
- 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-users, 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 involves 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 they should be measured

Examples of quality objectives 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 with respect to the provided service

Examples of process performance objectives include the following:
[PA165.IG101.SP101.SubP104.N103]

- Percentage of defects removed by product verification activities (perhaps by type, e.g. 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)
- Development cycle time
- Percentage of rework time

5. Derive interim objectives for each life-cycle stage, 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 review 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 includes 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 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 processes and process elements that comprise the project's defined process based on historical stability and capability data. *[PA165.IG101.SP102]*

Refer to the Integrated Project Management (IPPD) 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 that might include a new subprocess or 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 baseline 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
   - Product line standards
   - 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 organization's 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 baseline. 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). Risks may also occur when a selected subprocess has inadequate process performance data. [PA165.IG101.SP102.SubP104]

   Even when a subprocess has not been selected to be statistically managed, historical data and process performance models may indicate 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 to be Managed

Select the subprocesses of the project's defined process that will be statistically managed *[PA165.IG101.SP103]*

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. Select 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]

   It may not be possible to statistically manage some subprocesses (e.g., where new subprocesses and technologies are being pilot tested). In other cases it may not be economically justifiable to apply statistical techniques to certain subprocesses. [PA165.IG101.SP103.SubP102.N101]

   Examples of 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
   - Stable performance of the subprocess on other projects
   - Laws and regulations

3. 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 take 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 assess 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 life-cycle stage to assess progress toward achieving the project's quality and process performance objectives. [PA165.IG101.SP104.SubP102]
3. Track the 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 towards 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 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 for 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
- Accuracy of the organization's process performance models for predicting future performance
- Predicted process performance (estimated progress) are deficient
- 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 are 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

7. Track the identified actions to closure. [PA165.IG101.SP104.SubP107]

SG 2 Statistically Manage Subprocess Performance [PA165.IG102]

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

This goal summarizes a means for achieving the goal of "Able processes," by selecting and statistically managing those subprocesses of the project's defined process that are important to achieving the project's objectives. When the selected subprocesses are brought under statistical control, their capability to achieve their objectives can be determined, and by this means, it will be possible to predict whether the project will be able to achieve its objectives, and if not, take appropriate corrective action. [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 measures will be validated [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 organization's process assets that support the objectives of statistical management.

[PA165.IG102.SP101.SubP101]

Refer to the Organization 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]

Examples of additional measures include the following: [PA165.IG102.SP101.SubP102.N101]

- A certain work product and task attribute required by the customer (e.g., complexity) when the organization's standard work product and task attribute measure is size
- Defect categories specified by a regulatory agency
- Measures to address unique issues and concerns of the project

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?)
- 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 stages of the life cycle
- Percentage of the total effort expended in the different stages of the life cycle

4. Specify the operational definitions of the measures, their collection points in the subprocesses, and how the measures will be validated. [PA165.IG102.SP101.SubP104]

5. Analyze the relationship of the identified measures to the 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]

Refer to the Organizational Process Definition process area for more information about establishing and maintaining the organizational support environment. *[PA165.IG102.SP101.SubP106.R101]*

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 variance 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; and on verifying that collected measures are valid. *[PA165.IG102.SP102.R101]*

Understanding variation is achieved 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 variation is an unusual circumstance that causes an unexpected change in process performance. A transient circumstance can be a specific local condition, a single individual, or a small group of people performing in an unexpected way. Special causes are also known as "assignable causes" because they can be identified, analyzed, and addressed to prevent future problems. [PA165.IG102.SP102.N102]

Typical Work Products

1. Collected and verified measures including special causes of variation [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. 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 on the selected measures as the subprocesses execute. [PA165.IG102.SP102.SubP102]

3. Calculate the natural bounds of process performance for each measured attribute. [PA165.IG102.SP102.SubP103]

Examples 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]

16370 An example of a criterion for detecting a special cause of variation in a control
16371 chart is a data point that falls outside of the 3-sigma control limits.
16372 [PA165.IG102.SP102.SubP104.N101]

16373

16374 The criteria for detecting special causes of variation are based on statistical theory
16375 and experience and depend on economic justification. As criteria are added,
16376 special causes are more likely to be identified if present, but the likelihood of false
16377 alarms also increases. [PA165.IG102.SP102.SubP104.N102]

16378 5. Analyze the special cause of variation to determine the reasons the
16379 anomaly occurred. [PA165.IG102.SP102.SubP105]

16380 Examples of techniques for analyzing the reasons for special causes of variation
16381 include the following: [PA165.IG102.SP102.SubP105.N101]

16382 • Cause-and-effect (fishbone) diagrams
16383 • Designed experiments
16384 • Control charts (applied to subprocess inputs or to lower-level subprocesses)
16385 • Subgrouping (analyzing the same data segregated into smaller groups based on
16386 an understanding of how the subprocess was implemented facilitates isolation of
16387 special causes)

16388

16389 Some anomalies may simply be extremes of the underlying distribution rather
16390 than problems. The people implementing a subprocess are usually the ones best
16391 able to analyze and understand special causes of variation.
16392 [PA165.IG102.SP102.SubP105.N102]

16393 6. Take corrective action as appropriate when special causes of
16394 variation are identified. [PA165.IG102.SP102.SubP106]

16395 Removing a special cause of variation does not change the underlying
16396 subprocess. It addresses an error in the way the subprocess is being executed.
16397 [PA165.IG102.SP102.SubP106.N101]

16398 7. Recalculate the natural bounds for each measured attribute of the
16399 selected subprocesses as necessary. [PA165.IG102.SP102.SubP107]

16400 Recalculating the (statistically estimated) natural bounds is based on measured
16401 values that signify that the subprocess has changed, not on expectations or
16402 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 take 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
- Assess the probability of the process to meet it's quality and process performance objectives
- Take corrective action, 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. [PA165.IG102.SP103.N102]

Refer to the Causal Analysis and Resolution process area for more information about identifying and resolving special causes of process variation. *[PA165.IG102.SP103.N102.R101]*

A capable process is one that is stable and meets or exceeds its quality and performance objectives and can be expected to do so in the future. [PA165.IG102.SP103.N103]

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 that measured attribute. [PA165.IG102.SP103.SubP101]

   This comparison provides an assessment 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 a subprocess' process capability over time. [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's 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's process capability deficiency

5. Track the identified actions to closure. [PA165.IG102.SP103.SubP105]

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 requirements and objectives, and plans 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]*

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 tools used in performing the activities of the quantitative project management process include the following: [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, collection, and validation

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 measures will be validated
- Collectected and verified measures, including special cuases of variation

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: [PA165.EL109]

- Establishing project objectives
- Resolving issues among the project's quality and process performance objectives
- Assessing performance of the selected subprocesses
- Identifying and managing the risks in achieving the project's quality and process performance objectives
- Taking corrective action

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the quantitative project management process against the plan and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Quantitative Project Management process area 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]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the quantitative project management process and the work products and services of the process to the applicable requirements, objectives, and standards, 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 and verified measures including special causes of variation

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

Refer to the Model Components section of the Structure of the Model chapter of the Overview for more information about CMMI maturity levels. *[FM112.T101.R101]*

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 selects and deploys improvements that can improve the organization's ability to meet its quality and process performance objectives. 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 development cycle time
- Greater customer and end-user satisfaction
- Shorter development and 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. 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 incorporated into normal practice. [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]

16656 - A quantitative understanding of the organization's current quality
16657 and process performance
16658 - The organization's quality and process performance objectives
16659 - Estimates of the improvement in quality and process performance
16660 resulting from deploying the process and technology improvements
16661 - Estimated costs of deploying process and technology
16662 improvements, and the resources and funding available for such
16663 deployment

16664 The expected benefits added by the process and technology
16665 improvements are weighed against the cost and impact to the
16666 organization. Change and stability must be balanced carefully. Change
16667 that is too great or too rapid can overwhelm the organization, destroying
16668 its investment in organizational learning represented by the
16669 organization's process assets. Rigid stability can result in stagnation,
16670 allowing the changing business environment to erode the organization's
16671 business position. [PA161.N105]

16672 Improvements are deployed, as appropriate, to the following: [PA161.N106]

16673 - New projects
16674 - Ongoing development projects
16675 - Ongoing maintenance projects

16676 In this process area, the term ‘process and technology improvements’
16677 refers to incremental and innovative improvements to processes and
16678 also to process or product technologies. [PA161.N107]

16679 The practices in this process area complement and extend those found
16680 in the Organizational Process Focus process area. The focus of this
16681 process area is process improvement that is based on a quantitative
16682 knowledge of the organization’s set of standard processes and
16683 technologies and their expected quality and performance in predictable
16684 situations. In the Organizational Process Focus process area, no
16685 assumptions are made about the quantitative basis of improvement.
16686 [PA161.N108]

16687 ## Related Process Areas

16688 *Refer to the Organizational Process Definition process area for more*
16689 *information about incorporating the measures associated with the*
16690 *quantitative process improvement objectives into the organization’s*
16691 *common set of measures and incorporating the deployed process*
16692 *improvements into the organization’s process assets.* *[PA161.R101]*

Refer to the Organizational Process Focus process area for more information about soliciting, collecting, and handling of process improvement proposals and coordinating the deployment of the 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 defining the process and technology improvement measures related to the organization's business objectives, establishing measures and objectives to determine the value of selected process and technology improvements with respect to business objectives, and revising process and technology improvement measures. *[PA161.R105]*

Refer to the Integrated Project Management (IPPD) process area for more information about coordinating the deployment of process and technology improvements into the project's defined process. *[PA161.R106]*

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 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

- 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 [PA161.IG101]

Process and technology improvements that contribute to meeting quality and process performance objectives are selected.

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 of process assessments
   - An organization's process and technology improvement objectives
   - Analysis of data about customer problems and customer satisfaction
   - Analysis of data about project performance compared to quality and productivity objectives
   - Analysis of technical performance measures
   - Results of process and product benchmarks
   - 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 process and technology improvement 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 practices that cover 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 Innovations" specific practice. [PA161.IG101.SP101.SubP103.N101]

Whereas this specific practice analyzes proposals that have been passively collected, the purpose of the "Identify 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 from reviewing process and technology improvement proposals or by actively investigating and monitoring innovations that are in use in other organizations or 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 methodology). 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 cycles
- 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 those affected

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 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 candidate process and technology improvement. [PA161.IG101.SP101.SubP105]

6. Select the process and technology improvement proposals to be piloted before broad-scale 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 Innovations

Identify innovative improvements that would 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 and locate innovative improvements. This search primarily involves looking outside the organization. [PA161.IG101.SP102.N101]

Typical Work Products

1. Candidate innovation improvements [PA161.IG101.SP102.W101]

Subpractices

1. Analyze the organization's set of standard processes to determine areas where innovative improvements would be most helpful. [PA161.IG101.SP102.SubP101]

16896 These analyses are performed to determine which subprocesses are critical to
16897 achieving the organization's quality and process performance objectives and
16898 which ones are good candidates to be improved. [PA161.IG101.SP102.SubP101.N101]

16899 2. Investigate innovative improvements that may improve the
16900 organization's set of standard processes. [PA161.IG101.SP102.SubP102]

16901 Investigating innovative improvements involves the following:
16902 [PA161.IG101.SP102.SubP102.N101]

16903 • Systematically maintaining awareness of leading relevant technical work and
16904 technology trends

16905 • Periodically searching for commercially available innovative improvements

16906 • Collecting proposals for innovative improvements from the projects and the
16907 organization

16908 • Systematically reviewing processes and technologies used externally and
16909 comparing them to those used within the organization

16910 • Identifying areas where innovative improvements have been used successfully,
16911 and reviewing data and documentation of experience using these improvements

16912 3. Analyze potential innovative improvements to understand their
16913 effects on process elements and predict their influence on the
16914 process. [PA161.IG101.SP102.SubP103]

16915 Process performance models can provide a basis for analyzing possible effects of
16916 changes to process elements. [PA161.IG101.SP102.SubP103.N101]

16917 *Refer to the Organizational Process Performance process area for*
16918 *more information about process performance models.*
16919 *[PA161.IG101.SP102.SubP103.N101.R101]*

16920 Examples of such process performance models include: [PA161.IG101.SP102.SubP103.N102]

16921 • System dynamics models

16922 • Reliability growth models

16923 • Complexity models

16924

16925 4. Analyze the costs and benefits of potential innovative
16926 improvements. [PA161.IG101.SP102.SubP104]

16927 Innovative improvements that have a very large cost to benefit ratio are rejected.
16928 [PA161.IG101.SP102.SubP104.N101]

16929 5. Create process and technology improvement proposals for those
16930 innovative improvements that would result in improving the
16931 organization's processes or technologies. [PA161.IG101.SP102.SubP105]

16932 6. Select the innovative improvements to be piloted before broad-
16933 scale deployment. [PA161.IG101.SP102.SubP106]

16934 Since innovations, by definition, usually represent a major change, most
16935 innovative improvements will be piloted. [PA161.IG101.SP102.SubP106.N101]

16936 7. Document the results of the evaluations of innovative
16937 improvements. [PA161.IG101.SP102.SubP107]

16938 ## SP 1.3 Pilot Improvements

16939 ***Pilot process and technology improvements to select which ones***
16940 ***to implement.*** *[PA161.IG101.SP103]*

16941 Pilots are performed to assess new and unproven major changes
16942 before they are incorporated into normal practice, as appropriate.
16943 [PA161.IG101.SP103.N101]

16944 **Typical Work Products**

16945 1. Pilot evaluation reports [PA161.IG101.SP103.W101]

16946 2. Documented lessons learned from pilots [PA161.IG101.SP103.W102]

16947 **Subpractices**

16948 1. Plan the pilots. [PA161.IG101.SP103.SubP101]

16949 2. Review and get stakeholder agreement on the plans for the pilots.
16950 [PA161.IG101.SP103.SubP102]

16951 3. Consult with and assist the people performing the pilots.
16952 [PA161.IG101.SP103.SubP103]

16953 4. Perform each pilot in an environment that is characteristic of the
16954 environment present in a broad-scale deployment.
16955 [PA161.IG101.SP103.SubP104]

16956 5. Track the pilots against their plans. [PA161.IG101.SP103.SubP105]

16957 6. Review and document the results of pilots. [PA161.IG101.SP103.SubP106]

16958 Reviewing and documenting the results of pilots usually involves the following:
16959 [PA161.IG101.SP103.SubP106.N101]

16960 • Deciding whether to terminate the pilot, re-plan and continue the pilot, or proceed
16961 with deploying the process and technology improvement

16962 • Updating the disposition of process and technology improvement proposals
16963 associated with the pilot

16964 • Identifying and documenting new process and technology improvement proposals
16965 as appropriate

16966 • Identifying and documenting lessons learned and problems encountered during
16967 the pilot.

SP 1.4 Select Improvements for Deployment

Select process and technology improvement proposals for deployment across the organization. *[PA161.IG101.SP104]*

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 the following: [PA161.IG101.SP104.SubP103.N101]

   - Organization's 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 [PA161.IG102]

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

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 process improvement deployment plan 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 plans the deployment of the Organizational Innovation and Deployment process itself. [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 includes 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 business 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 projects' or organization's process performance
> - Number and type 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 measurement selection. *[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 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]*

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 deploying process and technology improvements quickly 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 the organization's process assets, as appropriate. [PA161.IG102.SP102.SubP104]

Refer to the Organizational Process Definition process area for more information about the organization's 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 the organization's 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 organization's process and technology assets.

   [PA161.IG102.SP102.SubP107]

Refer to the Organizational Training process area for more information about training materials. *[PA161.IG102.SP102.SubP107.R101]*

8. Verify 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

Refer to the Measurement and Analysis process area for more information about measurement selection. *[PA161.IG102.SP102.SubP110.N101.R101]*

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 measurement collection and analysis.
[PA161.IG102.SP103.R101]

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 quantitative objectives for process and technology improvement. [PA161.IG102.SP103.SubP103]

4. Analyze the progress toward achieving the organization's quantitative objectives for process and technology improvement 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 organizational 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 requirements and objectives, and plans for performing the organizational innovation and deployment process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are described in the organization's plan for organizational innovation deployment. This plan differs from the deployment plan for selected process and technology improvements described in the specific practice in this process area. The plan for organizational innovation deployment addresses strategic, high-level planning for all the organizational innovation deployment activities. The deployment plan addresses the implementation of selected process and technology improvement proposals. [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 tools used in performing the activities of the Organizational Innovation and Deployment process area include the following: [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]*

17203 **GP 2.5 (AB 5) Train People**

17204 ***Train the people performing or supporting the organizational***
17205 ***innovation and deployment process as needed.*** *[GP107]*

17206 Elaboration:

17207 Examples of training topics include the following: [PA161.EL103]

17208 • Planning, designing, and conducting pilots
17209 • Cost/benefit analysis
17210 • Technology transition
17211 • Change management

17212

17213 Directing Implementation

17214 **GP 2.6 (DI 1) Manage Configurations**

17215 ***Place designated work products of the organizational innovation***
17216 ***and deployment process under appropriate levels of configuration***
17217 ***management.*** *[GP109]*

17218 Elaboration:

17219 Examples of work products placed under configuration management
17220 include the following: [PA161.EL111]

17221 • Documented lessons learned from pilots
17222 • Revised process and technology improvement measures,
17223 objectives, priorities, and deployment plans
17224 • Updated training material

17225

17226 **GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders**

17227 ***Identify and involve the relevant stakeholders of the organizational***
17228 ***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 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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Organizational Innovation Deployment process area include the following: [PA161.EL106]

- Change in quality or 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]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational innovation and deployment process and the work products and services of the process to the applicable requirements, objectives, and standards, 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

Causal Analysis and Resolution 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 is the process of improving quality and productivity by preventing the introduction of defects into a product. Many development processes rely on defect detection and correction. However, reliance on detecting defects after they have been introduced is not cost effective. A more effective approach involves preventing defects from being introduced during development by integrating defect prevention activities into the development process. Causal analysis is applied during each stage of the development cycle. [PA155.N102]

Since defects and problems may have been previously encountered on other projects or in earlier stages 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 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. Such analysis may be initiated by improvement proposals, simulations, dynamic systems models, engineering analyses, new business directives, or other means. [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 are performed, and defect targets are selected for causal analysis. [PA155.N106]

A measurement process should already be in place. The defined measures can be used or 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 a measurement process. *[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 maturity level 4 process areas have been implemented, using terms like ‘common cause’ and ‘stable process.’ However, activities may be applicable with reduced value if this assumption is not met. [PA155.N110]

Related Process Areas

Refer to the Quantitative Project Management process area for more information about practices regarding 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 practices regarding 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 practices regarding the measurement of performance and performance change as a result of causal analysis and resolution actions. *[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

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 [PA155.IG101]

Root causes of defects and other problems are systematically determined.

A root cause is an antecedent source of a defect such that if it is removed, the defect is decreased or removed itself. [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 data may include the following: [PA155.IG101.SP101.SubP101.N101]
>
> - Project management problem reports requiring corrective action
> - Defects found in peer reviews
> - Defects found in testing
> - Process capability problems found from statistical analysis in managing the defined process

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]

> Examples of when to perform causal analysis include the following:
> [PA155.IG101.SP102.SubP101.N101]
>
> - When a stable process does not meet its specified product quality, service quality, or process performance objectives.
> - During the task, if and when the number of defects or the magnitude of identified problems warrants additional meetings
> - During the task, when the performance of a stable process needs to be improved to meet process performance objectives.
> - Periodically, during in-process tasks of long duration (e.g., a level-of-effort customer-support task)
> - Periodically, after products are released to the customer(s) (internal and external)
> - Shortly after the task is completed

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. Group the selected defects and other problems based on their causes. [PA155.IG101.SP102.SubP102]

> Examples of cause groups, or categories, include the following:
> [PA155.IG101.SP102.SubP102.N101]
>
> - Inadequate training
> - Breakdown of communications
> - Not accounting for all details of the problem
> - Making mistakes in manual procedures (e.g., typing)
> - Process deficiency

3. Analyze selected defects and other problems by group to determine their root causes. [PA155.IG101.SP102.SubP103]

Examples of methods to determine root causes include the following:
[PA155.IG101.SP102.SubP103.N101]

- Cause-and-effect (fishbone) diagrams
- Check sheets

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 kick-off 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
- Stage when the problem was introduced
- Stage when the defect was identified
- Description of the action proposal
- Action proposal category

SG 2 Address Causes of Defects [PA155.IG102]

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

Projects operating according to a well-defined process will systematically analyze the operation where problems still occur and implement process changes to eliminate common 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]*

Refer to the Measurement and Analysis process area for more information about how to evaluate and select action proposals. *[PA155.IG102.SP101.R101]*

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 plans for implementing selected proposals [PA155.IG102.SP101.W101]

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. Implement 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 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 project 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]

Refer to the Measurement and Analysis process area for more information about how to measure a change in performance. *[PA155.IG102.SP102.SubP101.R101]*

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]

Refer to the Measurement and Analysis process area for more information about how to measure process capability. *[PA155.IG102.SP102.SubP102.R101]*

This subpractice determines whether the selected change has positively influenced the ability of the process to meet its quality objectives, as determined by relevant stakeholders. [PA155.IG102.SP102.SubP102.N101]

17587 An example of a change in the capability of the project's defined design process
17588 would be the change in the ability of the process to stay within its process
17589 specification boundaries. This can be statistically measured by calculating the
17590 range of the defect density of design documentation, as collected in peer reviews
17591 before and after the improvement has been made. On a statistical process
17592 control chart, this would be represented by lowered control limits.
17593 [PA155.IG102.SP102.SubP102.N102]

17594

17595 ### SP 2.3 Record Data

17596 ***Record causal analysis and resolution data for use across the***
17597 ***project and organization.*** *[PA155.IG102.SP103]*

17598 Data are recorded so other projects and organizations can make
17599 appropriate process changes and achieve similar results.
17600 [PA155.IG102.SP103.N101]

17601 Record the following: [PA155.IG102.SP103.N102]

17602 - Data on defects and other problems that were analyzed
17603 - Rationale for decisions
17604 - Action proposals from causal analysis meetings
17605 - Action items resulting from action proposals
17606 - Cost of the analysis and resolution activities
17607 - Measures of changes to the performance of the defined process
17608 resulting from resolutions

17609 **Typical Work Products**

17610 1. Causal analysis and resolution records [PA155.IG102.SP103.W101]

17611 ## GG 3 Institutionalize a Defined Process [CL104.GL101]

17612 ***The process is institutionalized as a defined process.***

17613 Commitment to Perform

17614 ### GP 2.1 (CO 1) Establish an Organizational Policy

17615 ***Establish and maintain an organizational policy for planning and***
17616 ***performing the causal analysis and resolution process.*** *[GP103]*

Elaboration:

This policy establishes organizational expectations for identifying and systematically addressing common 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 requirements and objectives, and plans for performing the causal analysis and resolution process. *[GP104]*

Elaboration:

These requirements, objectives, and plans are described in the organization's plan for causal analysis and resolution. This plan differs from the action proposals and associated action plans described in the specific practice in this process area. The process action proposals and plans address the activities needed to remove the root cause under study; whereas the plan for causal analysis and resolution addresses the organization's overall process. [PA155.EL107]

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 tools used in performing the activities of the Causal Analysis and Resolution process area include the following: [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 plans for implementing selected proposals
- 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: [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 and take appropriate corrective action. *[GP110]*

Elaboration:

Examples of measures used in monitoring and controlling the activities of the Causal Analysis and Resolution process area 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]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the causal analysis and resolution process and the work products and services of the process to the applicable requirements, objectives, and standards, 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 plans for implementing selected proposals
- 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]*

17717 # Appendixes

17718 # A. References

17719 ## Publicly Available Sources

17720 The following documents were used in the development of the CMMI
17721 Product Suite and are publicly available.

Bate 95 Bate, Roger, et. al., *Systems Engineering Capability Maturity Model, Version 1.1,* Enterprise Process Improvement Collaboration and Software Engineering Institute, Carnegie Mellon University, November 1995. [SR121]

Crosby 79 Crosby, P. B. *Quality is Free* New York, New York: McGraw-Hill, 1979. [SR133]

Curtis 95 Curtis, Bill; Hefley, William E.; & Miller, Sally. *People Capability Maturity Model (CMU/SEI-95-MM-002).* Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University, September 1995. [SR132]

Deming 86 Deming, W. Edward *Out of the Crisis.* Cambridge, MA: MIT Center for Advanced Engineering, 1986. [SR131]

DoD 91 Department of Defense. *DoD Directive 5000.1: Defense Acquisition.* Washington, DC: Department of Defense, 1991. [SR106]

DoD 96a Department of Defense. *DoD Regulation 5000.2: Mandatory Procedures for Major Defense Acquisition Programs and Major Automated Information Systems.* Washington, DC: Department of Defense, 1996. [SR107]

DoD 96b Department of Defense. *DoD Guide to Integrated Product and Process Development (Version 1.0.)* Washington, DC: Office of the Under Secretary of Defense (Acquisition and Technology), February 5, 1996. Available WWW <URL:http://www.acq.osd.mil/te/survey/table_of_contents.html>. [SR112]

DoD 98 Department of Defense. *Defense Acquisition Deskbook, Version 3.2.* Available WWW <URL:

http://web2.deskbook.osd.mil/default.asp>. (Note this is continually updated.) [SR105]

Dunaway 96 Dunaway, D. & Masters, S. *CMM-Based Appraisal for Internal Process Improvement (CBA IPI): Method Description (CMU/SEI-96-TR-007).* Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University, April 1996. [SR130]

EIA 94 Electronic Industries Association. *EIA Interim Standard: Systems Engineering (EIA/IS-632).* Washington, D.C.: Electronic Industries Association, 1994. [SR108]

EIA 95 Electronic Industries Association. *EIA Interim Standard: National Consensus Standard for Configuration Management (EIA/IS-649).* Washington, D.C.: Electronic Industries Association, 1995. [SR124]

EIA 98 Electronic Industries Association. *Systems Engineering Capability Model (EIA/IS-731).* Washington, D.C.: Electronic Industries Association, 1998. Available WWW <URL: http://www.geia.org/eoc/G47/page6.htm> [SR126]

FAA 97 *Federal Aviation Administration-Integrated Capability Maturity Model, Version 1.0.* Available WWW <URL: http://www.faa.gov/ait/ait5/faa-icmm.htm>, November 1997. [SR109]

Ferguson 96 Ferguson, Jack; Cooper, Jack; Falat, Michael; Fisher, Matthew; Guido, Anthony; Marciniak, Jack; Matejceck, J.; & Webster, R. *Software Acquisition Capability Maturity Model Version 1.02 (CMU/SEI-96-TR-020).* Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University, December 1996. [SR118]

Herbsleb 97 Herbsleb, James; Zubrow, David; Goldenson, Dennis; Hayes, Will; & Paulk, Mark. *"Software Quality and the Capability Maturity Model."* Communications of the ACM 40, 6 (June 1977): 30-40. [SR129]

Humphrey 89 Humphrey, Watts S. *Managing the Software Process.* Reading, MA: Addison-Wesley, 1989. [SR128]

IEEE 90 Institute of Electrical and Electronics Engineers. *IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries.* New York, New York: Institute of Electrical and Electronics Engineers, 1990. [SR110]

INCOSE 96 *Systems Engineering Capability Assessment Model,*

Version 1.50, International Council on Systems Engineering, June 1996. [SR119]

ISO 87 International Organization for Standardization. *ISO 9000: International Standard.* New York, New York: International Organization for Standardization, 1987. [SR115]

ISO 95 International Organization for Standardization & International Electrotechnical Commission. *Information Technology: Software Life Cycle Processes (ISO 12207).* Geneva, Switzerland: International Organization for Standardization/International Electrotechnical Commission, 1995. [SR113]

JLC 96 Joint Logistics Commanders. *Practical Software Measurement: A Guide to Objective Program Insight.* Newport, RI: Department of the Navy, Naval Undersea Warfare Center, 1996. [SR127]

Juran 88 Juran, J. M. *Juran on Planning for Quality.* New York, New York: MacMillan, 1988. [SR134]

Masters 95 Masters, S. & Bothwell, C. *CMM Appraisal Framework (CMU/SEI-95-TR-001).* Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University, February 1995. [SR135]

Paulk 93 Paulk, M. C., Curtis, B., Chrissis, M. B., & Weber, C. V. *Capability Maturity Model for Software, Version 1.1 (CMU/SEI-93-TR-024, ADA 263403),* Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University, 1993. [SR122]

Paulk 98 Paulk, Mark. *Software Capability Maturity Model (SW-CMM®) Case Study Bibliography [online].* Available WWW <URL: http://www.sei.cmu.edu/activities/cmm/docs/roi.html> (1998). [SR136]

SEI 97 Software Engineering Institute. *Software CMM, Version 2 (Draft C).* Available WWW <URL:http://www.sei.cmu.edu/activities/cmm/draft-c/c.html>, Oct. 22, 1997. [SR123]

SEI 98 Software Engineering Institute. *CMMI A-Specification, Version 1.3* Available WWW <URL: http://www.sei.cmu.edu/cmm/cmmi/cmmi.spec.html>, July 15, 1998. [SR125]

SPMN 97 Software Program Managers Network. *Program Managers Guide to Software Acquisition Best Practices, Version V.2.* Available WWW <URL:

http://www.spmn.com/products_guidebooks.html>, April 1997. [SR117]

Sources Not Publicly Available

The following documents were used in the development of the CMMI Product Suite and are not publicly available.

Integrated Product Development Capability Maturity Model, Version 0.98, Enterprise Process Improvement Collaboration and Software Engineering Institute, Carnegie Mellon University, 1997. [SR111]

International Organization for Software. *ISO 15939 Software Measurement Process.* <URL: http://iso14001.net/iso15939/> [SR138]

International Organization for Software. *ISO 9001 The International Standard System for Assuring Product and Service Quality* [SR137]

International Organization for Standardization and International Electrotechnical Commission. *ISO/IEC 15504 Software Process Improvement and Capability dEtermination Model (SPICE).* <URL: http://www.esi.es/Projects/SPICE.html> [SR114]

Systems Engineering Capability Model, Interim Standard 731, Electronic Industries Alliance. Available WWW <URL: http://www.eiafoundation.org/eng/published.htm> [SR120]

Software Engineering Institute. *The Common CMM Framework (CCF) Draft E.* [SR103]

17725

B. Acronyms

AB	Ability to Perform (common feature)
ARC	Assessment 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-Integrated
CMMI-SE/SW	Capability Maturity Model-Integrated for Software Engineering and Systems 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 Association Interim Standard
GG	generic goal
GP	generic practice
IDEAL	Initiating, Diagnosing, Establishing, Acting, Leveraging
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
MOA	Memorandum of Agreement
M&A	Measurement and Analysis (process area)
OEI	Organizational Environment for Integration
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	Product and Process 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)
SAM	Supplier Agreement Management (process area)
SCAMPI	Standard CMMI Assessment Method for Process Improvement
SE-CMM	Systems Engineering Capability Maturity Model
SECAM	Systems Engineering Capability Assessment Model
SECM	Systems Engineering Capability Model
SE/SW	systems engineering and software engineering
SG	specific goal
SP	specific practice
SW-CMM	Capability Maturity Model for Software
TS	Technical Solution (process area)
Val	Validation (process area)
Ver	Verification (process area)
VI	Verifying Implementation (common feature)
WBS	work breakdown structure

17726

C. Glossary

The CMMI glossary defines many, but not all, terms used in the CMMI models. Glossary entries are typically multiple-word terms consisting of a noun and one or more restrictive modifiers. (There are some exceptions that are one-word terms.) [FM113.T101]

The glossary was developed using clear methods 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 except for in one process area. In either case, the use of the term is explained in the process area. [FM113.T102]

To be considered for the model glossary, terms must meet all of the following conditions: [FM113.T103]

Condition 1 - The entry must appear in the CMMI models. We excluded terms from the glossary that are self-explanatory in the context of the CMMI product or that, through popular use, already are widely understood by model users. We also excluded terms only used as examples and which were not concepts critical to the use of the model. However, if we had any doubt as to how widely understood a term was, we chose to include the term in the glossary. [FM113.T104]

Condition 2 - The definition of the term is not satisfied by common dictionary definition(s). We believe that the best reference source for term definitions is a standard English dictionary. Therefore, once a term was identified in the CMMI Product Suite, we looked up the term (or its component words) in WWWebster's (http://www.m-w.com). If the definition found there accurately characterized how the term was being used in CMMI products, we left the term 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, we found that the terms used in the CMMI models were unique to the CMMI context. In these instances, we created original definitions not found in other contexts. When selecting or creating CMMI definitions, we took great care 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 the model

You may notice that the term “process” is not defined in the glossary. The reason for its conspicuous absence is that it meets only one of the criteria for inclusion in the glossary. “Process” certainly appears in the model in multiple places (that is, it passes criteria 1). However, this term is defined adequately in the Webster’s dictionary and is not uniquely used in the CMMI models (that is, it fails criteria 2 and 3). [FM113.T107]

The Webster’s entry of “process” comprises multiple definitions, including those for the term as a noun, verb, or adjective. All of these definitions are valid; however, among them there is the following definition: “a series of actions or operations conducing to an end; especially a continuous operation or treatment especially in manufacture.” This definition most likely applies to most uses of the word “process” in CMMI products, but this word may also be used according to the other definitions provided in Webster’s. [FM113.T108]

When selecting definitions for terms in the CMMI glossary, we tried to use definitions from recognized sources where possible. Definitions were first selected from existing sources that have a widespread readership in the software and systems development domain. If we selected a definition from one of these sources, we included a note at the end of the definition in brackets (for example, [ISO 9000]). Our order of precedence 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 authors recognized the importance of using terminology that all model users can understand. We also recognize that words and terms can have different meanings in different contexts and environments. The CMMI model glossary is designed to capture 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 using a staged representation that describes the preconditions that must exist in the project or organization before the process can be consistently implemented. Ability to perform involves practices (including documenting the process and the plan); resource allocation (including people and tools); assignment of authority and responsibility; and training (including in-depth and overview training). (See also "staged representation" and "process area.")

acceptable alternative practice

A practice that is a substitute for one or more generic or specific practices and that are effective in implementing and institutionalizing the goal associated with the generic or specific practices. Alternative practices accomplish a result that meets the goal associated with the specific or generic practice that it is replacing.

acceptance criteria

The criteria that a product or product component must satisfy in order 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 also "integration testing," "regression testing," and "unit testing" for contrast)

achievement profile

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

A generic term covering all phases of acquisition, operation and logistics support of an item, beginning with concept definition and continuing through the disposal of the item.

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.
agreement/contractual requirements	All technical and non-technical 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 some generic or specific practices contained in the CMMI model. Alternative practices are not necessarily one-for-one replacements for the generic or specific practices.
assessment action plan	A detailed plan to address an assessment finding.
assessment class	A family of assessment methods that satisfy a defined subset of requirements in the Assessment Requirements for CMMI (ARC). These classes are defined so as to align with typical usage modes of assessment.
assessment finding	The results of an assessment that identify the most important issues, problems, or opportunities for process improvement within the assessment scope. Assessment findings are inferences drawn from validated observations.
assessment participants	Members of the organizational unit who participate in providing information during the assessment.
assessment rating	As used in CMMI assessment materials, the value assigned by an assessment 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 assessment method being employed.
assessment reference model	As used in CMMI assessment materials, the CMMI model to which an assessment team correlates process activities.
assessment scope	The definition of the boundaries of the assessment encompassing the organizational limits, the CMMI model limits, and the context within which the processes to be investigated operate.
assessment sponsor	The individual who authorizes an assessment, defines its goals and constraints, and commits to the use of the

assessment results.

assessment team leader

A person who leads the activities of an assessment.

assignable cause of process variation

In CMMI, the term "special cause of variation" is used in place of "assignable cause of 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 measure.”)

base practice

When using the continuous representation of CMMI, the base practices of a process area refer to all of the capability level one specific practices for the process area, or an equivalent alternative set.

baseline

1) An agreed-to description of the attributes of a product, at a point in time, which serves as a basis for defining change. (2) An approved and released document, or a set of documents, each of a specific revision; the purpose of which is to provide a defined basis for managing change. (3) The currently approved and released configuration documentation. (4) A released set of files comprising a software version and associated configuration documentation.

capability level

Achievement of process improvement within an individual process area. Activities within a capability level are described by generic practices and summarized by generic goals. (See "maturity level" for contrast. See also "process area," generic practice," and "generic goal.")

capability level profile

In continuous representations of CMMI models, a list of process areas and their corresponding capability levels. (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 climbing up 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 an ad hoc, immature process to a disciplined, mature process with improved quality and effectiveness.
capable process	A process that can satisfy its specified product quality, service quality, and process performance objectives. (See also "stable process," "standard process," "statistically managed process," and "well-defined 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 also "configuration management.")
CMMI appraisal questionnaire	A set of questions about practices and goals in each process area of the assessment reference model. Depending on the ARC compliant appraisal method being used, the CMMI Appraisal Questionnaire response summaries may provide assessors with guidance for scripting questions for interviews, help in identifying documents for review, provide information for use in crafting observations and findings, serve as an independent source of data for corroboration of observations, or be used to support model training.
CMMI assessment tailoring	Selection of options within the assessment method for use in a specific instance. The intent of tailoring is to assist an organization in aligning application of the method with its business objectives.
CMMI Framework	The basic structure that organizes CMMI products and components, which include common elements and best features of the current CMMI models as well as rules and methods for generating models, their assessment methods (including associated artifacts), and their training materials.
CMMI model	A model that describes the essential elements of an effective process for a discipline that is generated from the CMMI Framework and conforms to the framework's rules.
CMMI model component	Any of the main architectural elements that comprise a CMMI model. Some of the main elements of a CMMI model include specific practices, generic practices, specific goals, generic goals, process areas, capability levels, and maturity levels.
CMMI model	The use of a subset of a CMMI model for purposes of

tailoring	making it suitable for a specific application. The intent of tailoring is to assist an organization in aligning application of the model with its business objectives.
CMMI Product Suite	The set of products produced from the CMMI Framework including the framework itself. (See also "CMMI Framework.")
commitment to perform	A common feature of CMMI model process areas using a staged representation that describes the actions that the organization must take to ensure that the relevant process is established and will endure. (See also "staged representation" and "process area.") Commitment to perform involves practices on organizational policies (to set expectations for process performance) and senior management sponsorship (specifically for organizational process areas).
common cause of process variation	The variation of a process that exists because of normal and expected interactions among the components of a process. (See "special cause of process variation" for contrast.)
competency management	The continuously improving process used to enhance the capability of the staff to perform their assigned tasks and responsibilities, and to achieve specific competency growth objectives.
concept of operations	(See "operational concept.")
configuration audit	An audit conducted to verify that a configuration item conforms to a specified standard or requirement. (See also "audit" and "configuration item.")
configuration baseline	The configuration information formally designated at a specific time during a product's or product component's life cycle. Configuration baselines, plus approved changes from those baselines, constitute the current configuration information. (See also "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 also "configuration management," "configuration identification," and "configuration item.")
configuration control board	A group of people responsible for evaluating and approving or disapproving proposed changes to configuration items,

	and for ensuring implementation of approved changes. (See also "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 also "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 also "configuration management.")
configuration management	A management process for establishing and maintaining consistency of a product's performance, functional, and physical attributes with its requirements, design and operational information throughout its life.
configuration status accounting	An element of configuration management, consisting of the recording and reporting of information needed to manage a configuration effectively. This information includes a listing of the approved configuration identification, the status of proposed changes to the configuration, and the implementation status of approved changes. (See also "configuration management" and "configuration identification.")
configuration unit	The lowest-level configuration entity of a configuration item or component that should be placed into, and retrieved from, a configuration management library system. (See "configuration item" for contrast.)
continuous representation	A capability maturity model structure wherein capability levels provide a recommended order for approaching process improvement within each specified process area. (See "staged representation" for contrast. See also "capability level," and "process area,")
contractor	(See "supplier")
core competency	The knowledge and skills needed within the workforce to perform an important business function of the organization.
corrective action	Acts or deeds used to remedy a situation, remove an error, or adjust a condition.
critical design	A review conducted to verify that the detailed design of one

review	or more configuration items satisfies specified requirements; to establish the compatibility among the configuration items and other items of equipment, facilities, software, and personnel; to assess risk. (See also "configuration item.")
customer	The 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.
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	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 organization's process assets.
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" and "programmatic requirements" for contrast.)
design review	A formal, documented, comprehensive, and systematic examination of a design to evaluate the design requirements and the capability of the design to meet these requirements, and to identify problems and propose solutions.
detailed alternative solution	Detailed alternative solutions include the following: Cost (development, procurement/reprocurement, support, life cycle)t Technical Performance Complexity of the product component and related life cycle processes Robustness to product operating and use conditions,

operating modes, environments, and variations in related life cycle processes
Product expansion and growth
Technology limitations
Sensitivity to construction methods and materials
Risk
Evolution of requirement drivers and technology
Disposal

developmental configuration

In configuration management, the evolving product and associated documentation that define the evolving configuration of a configuration item during development. Note: The developmental configuration is under the developer's control, and therefore is not called a baseline. (See also "configuration item," and "configuration management.")

developmental plan

A plan for guiding, implementing, and controlling the design and development of one or more products. (See also "product life cycle.")

effectiveness analysis

An analytical approach to assess how well a design solution will perform or operate given anticipated environments, utilization rates, and operational scenarios. (See also "operational scenario.")

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 a 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," "capability level profile," and "target profile.") Such staging permits benchmarking of progress between organizations, enterprises, and projects, regardless of the CMMI representation used. The organization may use more of the model than what is reported as equivalent staging in its actual process improvement activities. Equivalent staging is only a measure to relate where the organization is compared to maturity levels.

establish and maintain

In CMMI model goal and practice statements, this phrase means establish, use, document, and maintain.

exit criteria

States of being that must be present before an effort can end successfully.

expected CMMI

CMMI components that explain what may be done to satisfy

components	a required CMMI component. Model users can follow the expected components explicitly or follow equivalent alternative practices to these components. Specific practices are expected model components.
finding	(see "assessment finding")
functional analysis	Examination of a defined function to identify all the sub-functions necessary to the accomplishment of that function; identification of functional relationships and interfaces (internal and external) and capturing these in a functional architecture; and flow down of upper-level performance requirements and assignment of these requirements to lower-level sub-functions. (See also "functional architecture.")
functional architecture	The hierarchical arrangement of functions, their internal and external (external to the aggregation itself) functional interfaces and external physical interfaces, their respective functional and performance requirements, and design constraints. (See also "functional baseline.)
functional baseline	The initially approved documentation describing a system's or product's functional performance, interoperability, and interface requirements and the verification required to demonstrate the achievement of those specified requirements. (See also "functional architecture."
generic goal	A goal attained by performing one or more practices that apply to multiple process areas. (See "quantitative objective," "organization's business objectives," "specific goal," and "quality objectives" for contrast.)
generic practice	A practice that is applicable to any process area, does not belong to a specific process area, and is important to stability and improvement within multiple process areas. (See also "process area.") Examples of generic practices are process planning, training, and configuration management.
goal	Required CMMI components that can be either generic goals or specific goals. Each goal within a process area must be achieved to consider the process area to be achieved. In CMMI models, the word "goal" is only used when referring to the model component.

incomplete process

A process that is not performed or only performed partially (also known as capability level 0). One or more of the specific goals of the process area are not satisfied.

informative CMMI components

CMMI components that help model users understand the required and expected components of the 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 building and reinforcement and corporate culture that support methods, practices, and procedures so that they are the ongoing way of doing business, even after those who originally defined them are gone.

integrated product and process development

Integrated Product and Process Development provides 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 cycle 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.

integration testing

Testing in which software components, hardware components, or both are combined and tested to evaluate the interaction between them. (See "acceptance testing," "regression testing," and "unit testing" for contrast.)

interface control

In configuration management, the process of: 1. identifying all functional and physical characteristics relevant to the interfacing of two or more configuration items provided by one or more organizations, and 2. ensuring the proposed changes to these characteristics are evaluated and approved prior to implementation. (See also "configuration management" and "configuration item.") [IEEE 828-1983]

Lead Assessor

As used in the CMMI Product Suite, a person who has demonstrated the necessary skills, competencies and experience for leading CMMI process assessments.

life cycle model	A partitioning of the life of a product into phases that guide the project from identifying customer needs through product retirement.
managed process	A performed process that is planned and executed in accordance with policy, employs skilled people having adequate resources to produce controlled outputs, involves stakeholders, and is reviewed and evaluated for adherence to requirements.
maturity level	Degree of process improvement across a predefined set of process areas in which all goals within the set are attained. (See "capability level" for contrast. See also "process area.")
memorandum of agreement or memorandum of understanding	Binding documents of understanding or agreements between two or more parties.
natural bounds	The inherent process reflected by measures and metrics of process performance, sometimes referred to as "voice of the process." Techniques such as control charts, confidence intervals, and prediction intervals are used to determine whether the variation is due to common causes (i.e., the process is predictable or "stable") or is due to some special cause that can and should be identified and removed.
non-developmental item	An item of supply that was developed 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.
non-technical 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 non-technical requirements include training requirements, site requirements, and deployment schedules.
objective evidence	As used in CMMI assessment 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 is based on observation, measurement, or test and which can be verified. [Adapted from ISO 10011:1994].
objective review	An evaluation of activities and work products against criteria that minimize subjectivity and bias by the reviewer. (See also "audit.") An example of an objective review is an audit against requirements, standards, or procedures by an independent quality assurance function.
objectively verify	Making sure what is done adheres to standards, policies, plans, requirements, etc. by using techniques that are applied by people who are not directly responsible for managing or performing the activities of the process.
observation	As used in CMMI assessment materials, a statement that represents the assessment team members' understanding of information either seen or heard during the assessment data collection activities.
operational concept	A general description of the way in which an entity is used or operates. (Also known as "concept of operations.)
operational documentation	Usually printed or printable instructions used to install, use, and maintain something.
operational scenario	A description of an imagined sequence of events that includes the interaction of the product with its environment and users, as well as interaction among its 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" and "defined process" for contrast. See also "common cause of process variation.")
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 "generic goal," "quantitative objective," "specific goal," and "quality objectives" for contrast.) 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 program	The set of related elements for addressing an organization's measurement needs. This set includes the definition of organization-wide measurements, methods, and practices.
organization's set of standard processes	The definition of the basic processes that are used as the basis for establishing common processes across the organization. It describes the fundamental process elements that are expected to be incorporated into the defined processes. It also describes the relationships (e.g., ordering and interfaces) between these process elements. (See also "defined process" and "process elements.")
organizational maturity	The extent to which an organization has explicitly and consistently deployed processes that are documented, manage, measured, controlled, and continually improved. Organization process maturity may be measured via a process appraisal.
organizational policy	A guiding principle, typically established by senior management that is adopted by an organization to influence and determine decisions.
organizational unit	That part of an organization that is the subject of an assessment. (See also "project.") [ISO/IEC TR 15504-9] An organizational unit deploys one or more processes that have a coherent process context and operates within a coherent set of business goals. An organizational unit is typically part of a larger organization, although in a small organization, the organizational unit may be the whole organization. An organizational unit may be, for example: a specific project or set of (related) projects; a unit within an organization focused on a specific lifecycle phase (or phases) such as acquisition, development, maintenance or support; a part of an organization responsible for all aspects of a particular product or product set.
outsourcing	(See "acquisition")
peer review	The review of work products performed by peers during the development of the work products to identify defects for removal.

performance parameters	The measures of effectiveness and other key metrics used to guide and control progressive development.
performed process	A process that accomplishes the needed work to produce identified output work products using identified input work products (also known as capability level 1). The specific goals of the process area are satisfied.
physical configuration audit	An audit conducted to verify that a configuration item, as built, conforms to the technical data package that defines it. (See also "audit" and "configuration item.")
planned process	A process that is documented both by a description and a plan. The description and plan should be coordinated, and the plan should include standards, requirements, objectives, resources, assignments, etc.
practice	Expected CMMI components that can be either generic practices or specific practices. Each practice within a process area, or an equivalent alternative must be achieved to consider the process area to be achieved. Every practice supports only one goal. (In CMMI models, the word "practice" is only used when referring to the model component).
process action team	A team that has the responsibility to develop and implement process improvement activities for an organization as documented in the process improvement action plan.
process area	A cluster of related practices in an area that, when performed collectively, achieve a set of goals considered important for establishing process capability in that area. (See also "process capability.")
process asset	Anything that the organization considers useful in attaining the goals of a process area. (See also "process area.")
process asset library	A collection of process asset holdings that can be used by an organization or project.
process capability	The extent to which a process is explicitly documented, managed, measured, controlled, and continually improved.
process capability baseline	A documented characterization of the range of expected results that would normally be achieved by following a specific process under typical circumstances.
process context	The set of factors, documented in the assessment plan that influences the judgment and comparability of assessment

ratings. These include, but are not limited to, the size of the organizational unit to be assessed, 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 database A repository into which all process data are entered. The database contains actual measurement data and related information needed to understand the measurement data and to assess it for reasonableness and applicability. Centralized control of this database ensures that the process data from all programs are permanently retained and protected.

process definition The act of defining and describing a process. The result of process definition is a process description. (See also "process description.")

process description A documented expression of a set of activities performed to achieve a given purpose that provides an operational definition of the major components of a process. The documentation specifies, in a complete, precise, and verifiable manner, the requirements, design, behavior, or other characteristics of a process. It also may include procedures for determining whether these provisions have been satisfied. Process descriptions may be found at the activity, project, or organizational level.

process element The fundamental unit of process description. A process may be defined in terms of subprocesses or process elements. A subprocess can be further decomposed; a process element is not decomposed into finer-grained descriptions.

process group A collection of specialists that facilitate the definition, maintenance, and improvement of the process(es) used by the organization.

process improvement A program of activities designed to improve the performance and maturity of the organization's processes and the results of such a program.

process improvement goals A set of target characteristics established to guide the effort to improve an existing process in a specific measurable way either in terms of resultant product characteristics (e.g., quality, performance, conformance to standards, etc.) or in the way in which the process is executed (e.g., elimination of redundant process steps, combining process steps, improving cycle time, etc.). (See "generic goal," "quantitative

goal," "organization's business goals," "specific goal," and "quality goals" for contrast.)

process 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 defined process. A process may therefore have multiple owners at different levels of responsibility. (See also "standard process" and "defined process.")

process performance

A measure of actual results achieved by following a process. It is characterized by both process measures (e.g., effort, cycle time, and defect removal efficiency) and product measures (e.g., reliability, defect density, and response time).

process performance baseline

A documented characterization of the actual results achieved by following a process, which is used as a benchmark for comparing actual process performance against expected process performance. (See also "process performance.")

process tailoring

To make, alter, or adapt a process description for a particular end. For example, a project tailors its defined process from the organization's set of standard processes to meet the objectives, constraints, and environment of the project. (See also "process description," "organization's set of standard processes," and "defined process.")

product

A product is a work product that is delivered to the customer.

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 also "configuration management" and "configuration item.") [derived from IEEE 610.12-1990]

product component

Any work product that must be engineered (requirements defined, designed, and integrated solution developed) to achieve the intended use of the product throughout its life cycle. Product components may be a part of the product delivered to the customer or 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; 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 also examples of product components.
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	The period of time that begins when a product is conceived and ends when the product is no longer available for use. [derived from IEEE 610.12-1990]
product line	A group of products sharing a common, managed set of features that satisfy specific needs of a selected market or mission.
product quality objectives	Specific objectives, which if met, provide a level of confidence that the quality of a product is satisfactory. (See "generic goal," "quantitative objective," "organization's business objectives," and "specific goal" for contrast.)
product requirements	A refinement of the customer requirements into the developers' language, making implicit requirements into explicit derived requirements. (See “product component requirements, "derived requirements," and "programmatic requirements" for contrast.) The developer uses the product requirements to guide the design and building of the product.
program	(1) A project (2) A collection of related projects and the infrastructure that supports them, including objectives, methods, activities, plans, and success measures. (See "project" for contrast.)
programmatic requirements	Those requirements that describe the non-technical contractual aspects of product development. (See “product component requirements, "derived requirements," and "product requirements" for contrast.) Examples of programmatic requirements include cost, schedule, reports, and reviews.
project	A managed set of interrelated resources that delivers one or more products to a customer or end user. This set of resources has a definite beginning and end and typically operates according to a plan. Such a plan is frequently documented and specifies the product to be delivered or implemented, the resources and funds used, the work to be

done, and a schedule for doing the work.

project manager

The person responsible for planning, directing, controlling, structuring, and motivating the project. (See also "project.")

project progress and performance

What a project achieves with respect to implementing project plans, including effort, cost, schedule, and technical performance.

prototype

A 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. [derived from IEEE 610.1990]
This model (physical, electronic, digital, analytical, etc.) can be used for the purpose of, but not limited to:
1. assessing the feasibility of a new or unfamiliar technology,
2. assessing or mitigating technical risk,
3. validating requirements,
4. demonstrating critical features,
5. qualifying a product,
6. qualifying a process,
7. characterizing performance or product features, or
8. elucidating physical principles.

quality

The ability of a set of inherent characteristics of a product, product component, or process to fulfill requirements of customers. [derived from ISO DIS 9000:2000].

quality assurance

A planned and systematic means for assuring management that defined standards, practices, procedures, and methods of the process are applied.

quality control

The operational techniques and activities that are used to fulfill requirements for quality. (For contrast, see “quality assurance.”) [ISO 8402-1994]

quality management system

All activities of the overall management function that determine the quality policy, objectives, and responsibilities, and implement them by means such as quality planning, quality control, quality assurance, and quality improvement within the quality management system.

quality planning

The activities that establish the objectives and requirements for quality and for the application of quality management system elements.

quantitative objective

Desired target value expressed as quantitative metrics. (See "generic goal," "organization's business objectives," "specific

goal," and "quality objectives" for contrast.)

quantitatively managed process

A defined process that is controlled using statistical and other quantitative techniques. The product quality, service quality, and process performance attributes are measurable and controlled throughout the life cycle. (See "optimizing process," "defined process," and "statistically managed process" for contrast.)

reference model

A model that is used as a benchmark for measuring some attribute.

regression testing

Testing to determine that a change to a product component has not adversely affected its physical attributes, functionality, reliability, or performance. (See "acceptance testing," " "integration testing," and unit testing" for contrast.)

required CMMI components

CMMI components that are essential to achieving process improvement in a given process area. These components are used in assessments 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 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 management	An organized, analytic process to identify what might cause harm or loss (identify risks), assess and quantify the identified risks, and to develop and, if needed, implement an appropriate approach to prevent or handle risk causes that could result in significant harm or loss.
risk mitigation strategies	The principles used to identify the activities that might be implemented to mitigate specific risks and identify the order in which risk mitigation activities are implemented.
root cause	A root cause is an antecedent source of a defect such that if it is removed, the defect is decreased or removed itself.
selection official	That individual within the organization who is authorized to select the offeror (and commit the organization) for award of a contract.
senior manager	A management role at a high enough level in an organization that the primary focus is the long-term vitality of the organization, rather than short-term project and contractual concerns and pressures. The senior manager has authority to direct the allocation or reallocation of resources in support of organizational process improvement effectiveness.
significant weakness	As used in CMMI assessment materials, a weakness that results in the rating of a CMMI model component to be "not satisfied."
software capability evaluation	A CMMI-based appraisal by a trained team of professionals to identify contractors who are qualified to perform the software work or to monitor the state of the software process used on an existing software effort.
software engineering	(1) The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software (2) The study of approaches as in (1). [derived from IEEE 610.12-1990]
solicitation	The process of preparing a solicitation package and selecting a supplier (contractor).
solicitation package	A formal document delineating technical and non-technical 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/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" for contrast.)
specific goal	A goal that is attained by performing specific practices within a process area. An organization must attain the associated goals of a process area to satisfy its requirements or the requirements of one of its capability levels. (See also "process area" and "capability level." See "generic goal," "quantitative objective," "organization's business objectives," and "quality objectives" for contrast.)
specific practice	A practice contained in a process area that describes an essential activity to, in part or in whole, accomplish a goal of the process area. (See also "process area" and "specific goal.")
stable process	The state in which all special causes of process variation have been removed and prevented from recurring so that only the common causes of process variation of the process remain. (See also "special cause of process variation" and "common cause of variation." See "standard process," "statistically managed process, "well-defined process," and "capable process" for contrast.)
staged representation	A capability maturity model structure wherein attaining the goals of a set of process areas establishes a maturity level; each level builds a foundation for subsequent levels. (See also "process area" and "maturity level.")
stakeholder	A group or individual that is affected by or is in some way accountable for the outcome of an undertaking.
standard	Mandatory requirements employed and enforced to prescribe a disciplined uniform approach to development.
standard process	An operational definition of the basic process that guides the establishment of a common process in an organization. (See also defined process) [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.
statement of work	A description of contracted work required to complete a project. (See also "project.")
statistical predictability	The performance of a quantitative process that is controlled using statistical and other quantitative techniques.

statistical process control	Statistically based analysis of a process and measurements of process performance, which will identify common and special causes of variation in the process performance, and maintain process performance within limits. (See also "common cause of process variation" and "special cause of process variation.")
statistical techniques	An analytic technique that employs statistical methods (e.g., statistical process control, confidence intervals, prediction intervals).
statistically managed process	A process that is managed by a statistically based technique in which processes are analyzed, special causes of variation are identified, and performance is contained within well-defined limits. (See "stable process," "standard process," "well-defined process," and "capable process" for contrast. See also "special cause of process variation.")
strength	As used in CMMI assessment materials, implementation of practices which, in the judgment of the assessment team, contribute to the satisfaction of a goal. Strengths related to CMMI models are effective implementations of one or more of the CMMI model practices or alternative practices.
subpractice	Practices listed beneath the specific and generic practices in CMMI models that describe activities that may be implemented in establishing the specific or generic practice. Subpractices are for informational purposes only and are intended to provide clarification of the practices or ideas for possible use by the user.
subprocess	A process that is part of a larger process. (See "process description.")
supplier	(1) The entity delivering product(s) or performing services being acquired (2) An individual, partnership, company, corporation, association or other service, having a agreement (contract) with an acquirer for the design, development, manufacture, maintenance, modification, or supply of items under the terms of a contract.
sustainment environment	An infrastructure (organizational structure, mission and functions, concept of operations, and resources (people, facilities, and funding)) necessary to sustain a product.
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 cycle. 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.

target profile

In continuous representations of CMMI models, a list of process areas and their corresponding capability levels that represent an objective for process improvement. (See "target staging," "capability level profile," "achievement profile," and "target profile.")

target staging

In continuous representations of CMMI models, a sequence of target profiles that describes the path of process improvement to be followed by the organization. This target staging must meet two requirements: It must be (1) monotone increasing and (2) admissible. (See "target staging," "capability level profile," "achievement profile," and "target profile.")

technical data package

The technical data package provides the description of a product or product component throughout the product life cycle. This description may support an acquisition strategy or the implementation, production, engineering, and logistics phases. A complete technical data package provides the following items to the extent applicable for a given product component:

- product component descriptions in terms of required life cycle functionality and performance
- developed 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/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 cycle
- rationale for decisions (requirements, requirement allocations, design choices)

technical requirements

Properties [attributes] of products or services to be acquired or developed.

test procedure

Detailed instructions for the set-up, execution, and evaluation of results for a given test case.

	evaluation of results for a given test case.
trade study	An evaluation of alternatives based on criteria and systematic analysis, to select the best alternative for attaining determined objectives.
unit testing	Testing of individual hardware or software units or groups of related units. (See "acceptance testing," "integration testing," and "regression testing" for contrast.)
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 assessment materials, the ineffective implementation of, or lack of, practices which, in the judgment of the assessment team, detract from or interfere with achievement of a goal.
well-defined process	A documented, consistent, and complete process that has specified entry criteria, inputs, task descriptions, verification descriptions and criteria, outputs, and exit criteria. (See "defined process," "stable process," "standard process," "statistically managed process," and "capable process" for contrast. See also "entry criteria" and "exit criteria.")
work breakdown structure	An arrangement of work elements and their relationship to each other and to the end product.
work product	Any artifact produced by a process. This may include files, documents, parts of the product, services, processes, specifications, and invoices. Examples of processes as work products include a manufacturing process, a training process, and a disposal process. A key distinction between a work product and a product component is that a work product need not be engineered.
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).

17811 # D. Required and Expected Model Elements

17812 # MATURITY LEVEL: 2

17813 # REQUIREMENTS MANAGEMENT

17814 **Maturity Level 2**

17815 The purpose of Requirements Management is to manage the
17816 requirements of the project's products and product components and to
17817 identify inconsistencies between those requirements and the project's
17818 plans and work products. [PA146]

17819 ## Specific and Generic Goals

17820 **SG 1 Manage Requirements**

17821 ***Requirements are managed and inconsistencies with project plans and work***
17822 ***products are identified.*** *[PA146.IG101]*

17823 **GG 2 Institutionalize a Managed Process**

17824 ***The process is institutionalized as a managed process.*** *[CL103.GL101]*

17825 ## Practices by Goal:

17826 **SG 1 Manage Requirements**

17827 ***Requirements are managed and inconsistencies with project plans and work***
17828 ***products are identified.*** *[PA146.IG101]*

17829 **SP 1.1 Obtain an Understanding of Requirements**

17830 ***Develop an understanding with the requirements providers on the***
17831 ***meaning of the requirements.*** *[PA146.IG101.SP101]*

17832 **SP 1.2 Obtain Commitment to Requirements**

17833 ***Obtain commitment to the requirements from the project***
17834 ***participants.*** *[PA146.IG101.SP102]*

17835 **SP 1.3 Manage Requirements Changes**

17836 ***Manage changes to the requirements as they evolve during the***
17837 ***project.*** *[PA146.IG101.SP103]*

17838 **SP 1.4 Maintain Bi-directional Traceability of Requirements**

17839 ***Maintain bi-directional traceability among the requirements and***
17840 ***the project plans and work products.*** *[PA146.IG101.SP104]*

17841 **SP 1.5 Identify Inconsistencies between Project Work and Requirements**

17842 ***Identify inconsistencies between the project plans and work***
17843 ***products and the requirements.*** *[PA146.IG101.SP105]*

17844 **GG 2 Institutionalize a Managed Process**

17845 ***The process is institutionalized as a managed process.*** *[CL103.GL101]*

17846 Commitment to Perform

17847 **GP 2.1 (CO 1) Establish an Organizational Policy**

17848 ***Establish and maintain an organizational policy for planning and***
17849 ***performing the requirements management process.*** *[GP103]*

17850 Ability to Perform

17851 **GP 2.2 (AB 1) Plan the Process**

17852 ***Establish and maintain the requirements and objectives, and plans***
17853 ***for performing the requirements management process.*** *[GP104]*

17854 **GP 2.3 (AB 2) Provide Resources**

17855 ***Provide adequate resources for performing the requirements***
17856 ***management process, developing the work products and***
17857 ***providing the services of the process.*** *[GP105]*

17858 **GP 2.4 (AB 3) Assign Responsibility**

17859 ***Assign responsibility and authority for performing the process,***
17860 ***developing the work products, and providing the services of the***
17861 ***requirements management process.*** *[GP106]*

17862 **GP 2.5 (AB 4) Train People**

17863 ***Train the people performing or supporting the requirements***
17864 ***management process as needed.*** *[GP107]*

17865 Directing Implementation

17866 **GP 2.6 (DI 1) Manage Configurations**

17867 ***Place designated work products of the requirements management***
17868 ***process under appropriate levels of configuration management.***
17869 *[GP109]*

17870 **GP 2.7 (DI 2) Identify and Involve Relevant Stakeholders**

17871 ***Identify and involve the relevant stakeholders of the requirements***
17872 ***management process as planned.*** *[GP124]*

17873 **GP 2.8 (DI 3) Monitor and Control the Process**

17874 ***Monitor and control the requirements management process***
17875 ***against the plan and take appropriate corrective action.*** *[GP110]*

17876 Verifying Implementation

17877 **GP 2.9 (VE 1) Objectively Evaluate Adherence**

17878 ***Objectively evaluate adherence of the requirements management***
17879 ***process and the work products and services of the process to the***
17880 ***applicable requirements, objectives, and standards, and address***
17881 ***noncompliance.*** *[GP113]*

17882 **GP 2.10 (VE 2) Review Status with Higher-Level Management**

17883 ***Review the activities, status, and results of the requirements***
17884 ***management process with higher-level management and resolve***
17885 ***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 and maintain a top-level work breakdown structure (WBS) to estimate of the scope of the project. *[PA163.IG101.SP101]*

SP 1.2 Establish Estimates of Project Attributes

Establish and document 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 attributes of 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 with identified stakeholders. *[PA163.IG102.SP106]*

17934 **SP 2.7 Establish the Project Plan**

17935 ***Establish and maintain the overall project plan content.***
17936 *[PA163.IG102.SP107]*

17937 **SG 3 Obtain Commitment to the Plan**

17938 ***Commitments to the project plan are established and maintained.*** *[PA163.IG103]*

17939 **SP 3.1 Review Subordinate Plans**

17940 ***Review subordinate plans to understand project commitments.***
17941 *[PA163.IG103.SP103]*

17942 **SP 3.2 Reconcile Work and Resource Levels**

17943 ***Reconcile the project plan to reflect available and projected***
17944 ***resources.*** *[PA163.IG103.SP101]*

17945 **SP 3.3 Obtain Plan Commitment**

17946 ***Obtain commitment from relevant stakeholders responsible for***
17947 ***performing and supporting plan execution.*** *[PA163.IG103.SP102]*

17948 **GG 2 Institutionalize a Managed Process**

17949 ***The process is institutionalized as a managed process.*** *[CL103.GL101]*

17950 Commitment to Perform

17951 **GP 2.1 (CO 1) Establish an Organizational Policy**

17952 ***Establish and maintain an organizational policy for planning and***
17953 ***performing the project planning process.*** *[GP103]*

17954 Ability to Perform

17955 **GP 2.2 (AB 1) Plan the Process**

17956 ***Establish and maintain the requirements and objectives, and plans***
17957 ***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 and take appropriate corrective action. *[GP110]*

Verifying Implementation

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the project planning process and the work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance. *[GP113]*

17985 **GP 2.10 (VE 2) Review Status with Higher-Level Management**

17986 ***Review the activities, status, and results of the project planning***
17987 ***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 understanding into 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 is 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 is 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. *[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 Correction 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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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 and services from suppliers external to the project 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 Analyze Needs and Requirements Determined by the Project

Analyze the project's needs and requirements that will be fulfilled by sources outside the project to determine how the needs and requirements will be satisfied. *[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 Acquire COTS Products

Acquire COTS products to 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 Conduct Acceptance Testing

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 requirements and objectives, and plans 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 and take appropriate corrective action. *[GP110]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the supplier agreement management process and the work products and services of the process to the applicable requirements, objectives, and standards, 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 practices 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 practices 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 affected 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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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 the 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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance. *[GP113]*

18325 **GP 2.10 (VE 2) Review Status with Higher-Level Management**

18326 ***Review the activities, status, and results of the process and***
18327 ***product quality assurance process with higher-level management***
18328 ***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 and maintained. *[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 and maintained. *[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 Changes

Track change requests for the configuration items. *[PA159.IG102.SP101]*

SP 2.2 Control Changes

Control changes to the content of 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 requirements and objectives, and plans 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 and take appropriate corrective action. *[GP110]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the configuration management process and the work products and services of the process to the applicable requirements, objectives, and standards, 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]*

18415 # 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 for the product life cycle. *[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's 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 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's life cycle.

[PA157.IG101.SP101]

SP 1.2 Transform Stakeholder Needs, Expectations, Constraints, and Interfaces into 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 for the product life cycle. *[PA157.IG103]*

SP 2.1 Establish Product and Product Component Requirements

Establish and maintain, from the customer requirements, product and product component requirements essential to product and product component effectiveness and affordability. *[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 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 derived requirements to ensure that they are necessary and sufficient. *[PA157.IG102.SP103]*

SP 3.4 Evaluate Product Cost, Schedule and Risk

Analyze requirements with the purpose of reducing the life-cycle cost, schedule and risk of product development. *[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 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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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 develop, design, and implement solutions to requirements. Solutions, designs and implementations encompass products, product components, and product related processes either singly or in combinations as appropriate. [PA160]

Specific and Generic Goals

SG 1 Select Product Component Solutions

Product or product component solutions, including applicable product related processes, 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, including applicable product related processes, 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 only as informative material.

SP 1.1-1 Develop Alternative Solutions and Selection Criteria

Develop alternative solutions and establish 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 Use Effective Design Methods

Establish and use effective design methods. *[PA160.IG102.SP101]*

SP 2.2 Establish a Complete Technical Data Package

Establish and maintain a complete technical data package. *[PA160.IG102.SP103]*

The following specific practice appears in the continuous representation as SP 2.2-1, but is subsumed in the staged representation by SP 2.2 Establish a Complete Technical Data Package . The specific practice is presented here only as informative material.

SP 2.2-1 Develop a Technical Data Package

Develop a product or product component technical data package. *[PA160.IG102.SP102]*

SP 2.3 Design Comprehensive Interface

Design 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 Comprehensive Interface . The specific practice is presented here 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 Establish Product Support Documentation

Establish 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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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

The strategy for conducting product integration is established and maintained. *[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

The strategy for conducting product integration is established and maintained. *[PA147.IG101]*

SP 1.1 Establish a Product Integration Strategy

Establish and maintain a strategy for integration of the product components. *[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 Define Detailed Product Integration Procedures

Define detailed 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 identifed, 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 strategy. *[PA147.IG103.SP102]*

SP 3.3 Checkout Assembled Product Components

Checkout an assembly of product components. *[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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, and address noncompliance. *[GP113]*

18762 **GP 2.10 (VE 2) Review Status with Higher-Level Management**

18763 ***Review the activities, status, and results of the product integration***
18764 ***process with higher-level management and resolve issues.*** *[GP112]*

VERIFICATION

Maturity Level 3

The purpose of Verification is to assure 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 Establish a Verification Strategy

Establish and maintain a verification strategy for selected work products. *[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 Detailed Verification Plans

Establish and maintain detailed verification plans for 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 according to the verification strategy.
[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]*

SP 3.3 Perform Re-Verification

Perform re-verification of corrected work products and ensure that work products have not been negatively impacted. *[PA150.IG103.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 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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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 Establish a Validation Strategy

Establish and maintain a validation strategy. *[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 Define Detailed Validation Procedures

Define detailed procedures and criteria for validation. *[PA149.IG101.SP103]*

18885 **SG 2 Validate Product or Product Components**

18886 ***The product or product components are validated to ensure that they are***
18887 ***suitable for use in their intended operating environment.*** *[PA149.IG102]*

18888 **SP 2.1 Perform Validation**

18889 ***Perform validation according to the validation strategy.***
18890 *[PA149.IG102.SP101]*

18891 **SP 2.2 Capture and Analyze Validation Results**

18892 ***Capture and analyze the results of the validation activities and***
18893 ***identify issues.*** *[PA149.IG102.SP102]*

18894 **GG 3 Institutionalize a Defined Process**

18895 ***The process is institutionalized as a defined process.*** *[CL104.GL101]*

18896 Commitment to Perform

18897 **GP 2.1 (CO 1) Establish an Organizational Policy**

18898 ***Establish and maintain an organizational policy for planning and***
18899 ***performing the validation process.*** *[GP103]*

18900 Ability to Perform

18901 **GP 3.1 (AB 1) Establish a Defined Process**

18902 ***Establish and maintain the description of a defined validation***
18903 ***process.*** *[GP114]*

18904 **GP 2.2 (AB 2) Plan the Process**

18905 ***Establish and maintain the requirements and objectives, and plans***
18906 ***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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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 establish and maintain an understanding of the organization's processes and process assets, and to identify, plan, and implement the organization's process improvement activities. [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, process assets are deployed, and process-related experiences are incorporated into the organization's 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 Assess the Organization's Processes

Assess 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 related process assets. *[PA152.IG101.SP103]*

SG 2 Plan and Implement Process Improvement Activities

Improvements are planned and implemented, process assets are deployed, and process-related experiences are incorporated into the organization's 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 related 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 Process and Related Process Assets

Deploy the process and related process assets across the organization. *[PA152.IG102.SP103]*

SP 2.4 Incorporate Process-Related Experiences into the Organization's Process Assets

Incorporate process-related work products, measures, and improvement information derived from planning and performing the process into the organization's 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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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]*

19042 ## ORGANIZATIONAL PROCESS DEFINITION

19043 **Maturity Level 3**

19044 The purpose of Organizational Process Definition is to establish and
19045 maintain a usable set of organizational process assets. [PA153]

19046 ### Specific and Generic Goals

19047 **SG 1 Create Organizational Process Assets**

19048 ***A set of organizational process assets is available.*** *[PA153.IG101]*

19049 **SG 2 Make Supporting Process Assets Available**

19050 ***Process assets that support the use of the organization's set of standard***
19051 ***processes are available.*** *[PA153.IG102]*

19052 **GG 3 Institutionalize a Defined Process**

19053 ***The process is institutionalized as a defined process.*** *[CL104.GL101]*

19054 ### Practices by Goal:

19055 **SG 1 Create Organizational Process Assets**

19056 ***A set of organizational process assets is available.*** *[PA153.IG101]*

19057 **SP 1.1 Establish Standard Processes**

19058 ***Establish and maintain the organization's set of standard***
19059 ***processes.*** *[PA153.IG101.SP101]*

19060 **SP 1.2 Establish Life-Cycle Model Descriptions**

19061 ***Establish and maintain descriptions of the life-cycle process***
19062 ***models approved for use in the organization.*** *[PA153.IG101.SP102]*

19063 **SP 1.3 Establish Tailoring Criteria and Guidelines**

19064 ***Establish and maintain the tailoring criteria and guidelines for the***
19065 ***organization's set of standard processes.*** *[PA153.IG101.SP103]*

SG 2 Make Supporting Process Assets Available

Process assets that support the use of the organization's set of standard processes are available. *[PA153.IG102]*

SP 2.1 Establish an Organizational Measurement Repository

Establish and maintain an organizational measurement repository *[PA153.IG102.SP101]*

SP 2.2 Establish an Organizational Process Asset Library

Establish and maintain the organization's library of process-related assets. *[PA153.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 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 requirements and objectives, and plans 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 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]*

GP 2.9 (VE 1) Objectively Evaluate Adherence

Objectively evaluate adherence of the organizational process definition process and the work products and services of the process to the applicable requirements, objectives, and standards, 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 Identify Training Needs and Make Training Available

Training to support the organization's management and technical roles is identified and made available. *[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 Identify Training Needs and Make Training Available

Training to support the organization's management and technical roles is identified and made available. *[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 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 an organizational training 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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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 (IPPD)

Maturity Level 3

The purpose of Integrated Project Management (IPPD) 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. It 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]

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

The project is conducted using the project's shared vision. *[PA167.IG103]*

SG 4 Organize Integrated Teams

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 organization's 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 subordinate plans 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 subordinate plans, and the project's defined process. *[PA167.IG101.SP104]*

SP 1.5 Contribute to the Organization's Process Assets

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

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

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 (IPPD) 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 (IPPD) process. *[GP114]*

GP 2.2 (AB 2) Plan the Process

Establish and maintain the requirements and objectives, and plans for performing the integrated project management (IPPD) process. *[GP104]*

GP 2.3 (AB 3) Provide Resources

Provide adequate resources for performing the integrated project management (IPPD) 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 (IPPD) process. *[GP106]*

GP 2.5 (AB 5) Train People

Train the people performing or supporting the integrated project management (IPPD) process as needed. *[GP107]*

Directing Implementation

GP 2.6 (DI 1) Manage Configurations

Place designated work products of the integrated project management (IPPD) 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 (IPPD) process as planned. *[GP124]*

GP 2.8 (DI 3) Monitor and Control the Process

Monitor and control the integrated project management (IPPD) process against the plan 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 (IPPD) 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 (IPPD) process and the work products and services of the process to the applicable requirements, objectives, and standards, 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 (IPPD) 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 cycle 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 classify 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 and methods 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, Classify, and Prioritize Risks

Evaluate and classify 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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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]*

19445 ## INTEGRATED TEAMING

19446 **Maturity Level 3**

19447 The purpose of Integrated Teaming is to form and sustain an integrated
19448 team for the development of work products. [PA170]

19449 ### Specific and Generic Goals

19450 **SG 1 Establish Team Composition**

19451 ***Team composition that provides the knowledge and skills required to deliver***
19452 ***the team's product is established and maintained.*** *[PA170.IG101]*

19453 **SG 2 Govern Team Operation**

19454 ***Operation of the integrated team is governed according to established***
19455 ***principles.*** *[PA170.IG102]*

19456 **GG 3 Institutionalize a Defined Process**

19457 ***The process is institutionalized as a defined process.*** *[CL104.GL101]*

19458 ### Practices by Goal:

19459 **SG 1 Establish Team Composition**

19460 ***Team composition that provides the knowledge and skills required to deliver***
19461 ***the team's product is established and maintained.*** *[PA170.IG101]*

19462 **SP 1.1 Identify Team Tasks**

19463 ***Identify and define the team's specific internal tasks to generate***
19464 ***the team's expected output.*** *[PA170.IG101.SP101]*

19465 **SP 1.2 Identify Needed Knowledge and Skills**

19466 ***Identify the knowledge, skills, and functional expertise needed to***
19467 ***perform team tasks.*** *[PA170.IG101.SP102]*

19468 **SP 1.3 Assign Appropriate Team Members**

19469 ***Assign the appropriate personnel to be team members based on***
19470 ***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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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 make decisions using a structured approach 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 and Use Guidelines for Decision Analysis

Establish and use guidelines to determine which issues are subject to a structured decision analysis and resolution process.

[PA156.IG101.SP101]

SP 1.2 Select Decision-Making Techniques

Select the decision-making techniques. *[PA156.IG101.SP102]*

SP 1.3 Establish Evaluation Criteria

Establish the evaluation criteria and their relative ranking.

[PA156.IG101.SP103]

SP 1.4 Identify Alternative Solutions

Identify alternative solutions to issues. *[PA156.IG101.SP104]*

SP 1.5 Evaluate Alternatives

Evaluate alternative solutions using the documented criteria. *[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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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]*

19622 # ORGANIZATIONAL ENVIRONMENT FOR INTEGRATION

19623 **Maturity Level 3**

19624 The purpose of Organizational Environment for Integration is to provide
19625 an IPPD infrastructure and manage people for integration. [PA169]

19626 ## Specific and Generic Goals

19627 **SG 1 Provide IPPD Infrastructure**

19628 ***An infrastructure that maximizes the productivity of people and effects the***
19629 ***collaboration necessary for integration is provided.*** *[PA169.IG101]*

19630 **SG 2 Manage People for Integration**

19631 ***People are managed to nurture the integrative and collaborative behaviors of***
19632 ***an IPPD environment.*** *[PA169.IG102]*

19633 **GG 3 Institutionalize a Defined Process**

19634 ***The process is institutionalized as a defined process.*** *[CL104.GL101]*

19635 ## Practices by Goal:

19636 **SG 1 Provide IPPD Infrastructure**

19637 ***An infrastructure that maximizes the productivity of people and effects the***
19638 ***collaboration necessary for integration is provided.*** *[PA169.IG101]*

19639 **SP 1.1 Establish the Organization's Shared Vision**

19640 ***Establish and maintain a shared vision for the organization.***
19641 *[PA169.IG101.SP101]*

19642 **SP 1.2 Establish an Integrated Work Environment**

19643 ***Establish and maintain an integrated work environment that***
19644 ***supports IPPD by enabling collaboration and concurrent***
19645 ***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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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]*

19717 # 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, 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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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 processes and process elements that comprise the project's defined process based on historical stability and capability data. *[PA165.IG101.SP102]*

SP 1.3 Select the Subprocesses to be 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 take 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 variance 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 take 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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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]*

19908 # 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 Innovations

Identify innovative improvements that would 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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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 requirements and objectives, and plans 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 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 and the work products and services of the process to the applicable requirements, objectives, and standards, 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]*

E. CMMI Project Participants

The following people were involved in the CMMI project as product development team members, steering group members, or members of the stakeholder/reviewer team. [FM116.T101]

Ahern, Dennis
Albert, Cecilia
Allgood, Bruce
Angstadt, Kim
Armstrong, Jim
Austin, Darryl
Bailey, Mike
Baker, Michele
Barsotti, Dennis
Basili, Victor
Bate, Roger
Baxter, Brent
Bennett, Dan
Beshore, David
Billi, Joseph
Blasewitz, Bob
Blazy, Louis
Blyler, John
Brayer, Gil
Briganti, Kristine
Brown, Alan
Brown, Leroy
Capell, Peter
Carter, Dennis
Castellano, Dave
Cattan, Denise
Cavanaugh, Mark
Cepeda, Sandra
Chittister, Clyde
Chrissis, Mary Beth
Clouse, Aaron
Cole, David
Conrad, Tom
Consiglio, John
Costello, Joe
Coyle, Thomas
Craig, Rushby
Criss, William
Cukor, Jeff
Denny, Barbara
DeWolf, Barton
Doran, Terry
Fantazier, Bob
Farinello, Joe
Ferguson, Dr. Jack
Fritz, Nick
Gaeta, Rob
Goldenson, Dennis
Graffius, Joe
Gramoy, Beth
Gray, Lewis
Green, Dan
Gross, Jon
Guerin, Joan
Gunning, Kelly
Haas, Sue
Haggerty, Chad
Hayes, Will
Hefner, Rick
Heijstek, Andre
Herman, Jeff
Hodyke, Andrew
Hollenbach, Craig
Ibrahim, Linda
Irion-Talbot, Wendy
Iyer, Seshadri
Jacobs, Debbie
Jarzombek, Joe
Johnson, Martha
Jones, Lawrence
Kansala, Kari
Karandikar, Harsh
Kayuha, Bob
Keeler, Kristi
Kellner, Marc
Kellogg, David
Kelly, Susanne
Kirschbaum, Alan
Kitson, Dave
Kitson, Loretta J.
Kohl, Ron
Konrad, Mike
Kopcho, Joanne
Kordik, John

[FM116.T102]

Kormos, Christina
Kosco, Don
Koshetar, Paul
Langhout, Jacquelyn
Lanier, Kelly
Lentz, Robert
Le, Hien
Loebig, Kathleen
Madhavan, Pg
Malpass, Peter
Marciniak, John
Martin, Rich
Matthews, Jeanne
McConnell, David
McNeill, Bob
McSteen, Bill
Menezes, Winifred
Midha, Anil
Miluk, Gene
Mogilensky, Judah
Moon, Jane
Moore, James
Moore, Richard
Mosley, Mark
Mounts, Darryl
Nash, Dan
Nauman, Matt
Newberry, George
Norimatsu, So
Ourada, Gerald
Parker, Thomas
Parry, Thomas
Patterson, Bob
Paulk, Mark
Peterson, Bill
Pflugrad, Alan
Phillips, David M. (Mike)
Pillai, R.
Pinkney, Lisa
Pomietto, Robert J.
Prange, Mark
Raphael, Richard
Rassa, Bob
Rawat, A
Richins, Kevin
Richter, Karen
Riddle, Bill
Rogoway, Paul
Salomon, Arthur
Sautter, John
Schoening, Bill
Scott, Terry
Sherer, Wayne
Shioya, Kazunori
Shrum, Sandy
Shuster, David
Sleder, Al
Smith, Dudrey
Steiner, Cliff
Stewart, Lee
Stratton, Duane
Svolou, Agapi
Tady, Carolyn
Tavan, Steve
Taylor, Guy D.
Totty, Lonnie
Trebbien-Nielsen, Claus
Turner, Richard
Tyson, Barbara A.
Vernick, Judy A.
Waina, Richard
Weber, Charles
Wells, Curt
Weszka, Joan
White, Barbara
White, David
Wilson, Hal
Wolf, Gary
Yeats, James
Zubrow, Dave

20101 [FM116.T103]