The Federal Aviation Administration Integrated Capability Maturity Model® (FAA-iCMM®), Version 2.0

An Integrated Capability Maturity Model for Enterprise-wide Improvement

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This work has been developed in part by adapting portions of the following documents. A complete list of sources and references is provided in Appendix C of this document.

Systems Engineering Capability EIA/IS 731, EIA Interim Standard, Electronic Industries Association, 1998

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The President's Quality Award Program 2000, published by United States Office of Personnel Management (public domain material)

The Malcolm Baldrige National Quality Award Program 2000, published by United States Department of Commerce, National Institute of Standards and Technology (public domain material)

CMMI^{SM} for Systems Engineering/Software Engineering/Integrated Product and Process Development, Version 1.02 (CMMI^{SM}-SE/SW/IPPD, V1.02)
Continuous Representation, CMU/SEI-2000-TR-031, ESC-TR-2000-096.

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Foreword

From the Administrator

The FAA's vision is to provide the safest, most efficient and responsive aerospace system in the world, and to be the best Federal employer, continuously improving service to customers and employees. In pursuit of our vision, we need to continuously improve our performance, our products, and our services. One key to success is developing results oriented processes that permit us to perform our tasks with quality and discipline.

This document contains Version 2.0 of the FAA integrated Capability Maturity Model (iCMM) which provides a framework for ongoing process improvement. Many performance gains have been realized during the past several years as a result of using Version 1.0 of the iCMM. Version 2.0 improves the iCMM by including guidance and best practices from several additional widely recognized models and standards such as the Malcolm Baldrige National Quality Award criteria.

We in the FAA continue to focus our attention on delivering the best service possible to our aviation customers on a daily basis and on accelerating the implementation of near-term improvements in safety, security, and system efficiency. It is important to realize that our achievements are enhanced when they are based on high performance processes throughout the agency. The FAA-iCMM provides a path that is crucial to helping us achieve these improvements.

Jane Garvey
Administrator

Foreword

From the Deputy Assistant Administrator for Information Services and Deputy Chief Information Officer

Version 1.0 of the iCMM was released in November 1997 and has been the framework for most process improvement among the technical and engineering organizations within the FAA since then. The release of Version 2.0 of the FAA-iCMM is the next logical step towards achieving an enterprise-wide approach to process improvement. Version 2.0 incorporates lessons learned from four years of experience with Version 1.0. Additionally, it updates the model to include best practices and concepts from several new standards for process improvement, including ISO 9001:2000, EIA/IS 731, and the CMMI, making this a framework that can truly support process improvement across the whole FAA. It further broadens the model by incorporating high performance business perspectives of the President's Quality Award and Malcolm Baldrige National Quality Award criteria. Given the immense challenges facing the FAA, having a single model on which to base its process improvements is a real advantage. The alternate approach of using multiple standards is simply too expensive, too confusing, and too difficult.

I believe version 2.0 is the most ambitious and thorough integration of process improvement standards anywhere. The FAA remains in the forefront of advancing how large organizations improve their processes. Of course, we will continue to share our experiences with others in the community in the hope that our efforts will inform others who experience similar challenges.

As the primary sponsor for this effort, I am especially proud of the team that developed this new version of the model. It gives me great pleasure to see their hard work reach fruition. I look forward to the widespread application of this model within the FAA.

Art Pyster

Acknowledgments

Version 2.0 of the FAA integrated Capability Maturity Model® (FAA-iCMM®) is the collaborative work of many individuals[1]. There were many roles to play and the authors are grateful to all those who contributed.

First, we are deeply indebted to Art Pyster, Chair of the FAA integrated Process Group (iPG), our sponsor and advisor, for his constant support and advocacy of this effort.

We thank the iPG sponsors who have embodied their commitment to FAA process improvement in performance goals linked to achieving improvements based on the FAA-iCMM, and we express our appreciation to the iPG members for providing valuable oversight as the project evolved and progressed. The iPG Configuration Control Board approved the final version of this product and we thank them for their diligence and contributions.

Key external reviewers attended a workshop with the authors, providing an exhilarating forum for exchange of ideas, and we are very grateful for their participation in this effort.

We would like to thank our "buddies" for providing special domain knowledge and for participating in peer reviews.

We are especially gratified and indebted to our internal and external reviewers who participated by providing over 800 comments on various drafts of the model.

We thank our stakeholders -- the many FAA organizations, programs, process groups and process action teams -- for their dedication in using version 1.0 of the model, and for identifying areas of improvement incorporated in version 2.0. We acknowledge in advance the valuable feedback we anticipate from them as we continue to validate, evolve and improve the model based on its use in process improvement.

Special thanks are extended to Roger Cooley for supporting and advocating the project in a variety of ways.

Lastly, we wish to extend our appreciation to those individuals who provided editorial and administrative assistance in the handling, preparation, and publication of this document. They are: Nancy Depoy of BAE Systems and Andrea Haines of TRW.

Thank you all for your valued contribution.

[1] Please refer to section 1.3 of Chapter 1 for a list of project participants.

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The FAA-iCMM Version 2.0

An Integrated Capability Maturity Model for Enterprise–wide Improvement

Table of Contents

Forewords
Acknowledgments

Part 1: Overview Information
- Chapter 1: Introduction
  - 1.1 About this Document
  - 1.2 Background
  - 1.3 About the FAA-iCMM Project
- Chapter 2: Overview of the Model
  - 2.1 Key Concepts and Definitions
  - 2.2 Architecture Description
  - 2.3 Capability Dimension
  - 2.4 Capability Level Summaries
  - 2.5 Process Dimension
  - 2.6 Process Area Summaries
  - 2.7 Maturity Levels and Staging
  - 2.8 Generic Attributes
- Chapter 3: Using the Model
  - 3.1 Usage Contexts
  - 3.2 Using the iCMM to Support Process Improvement
  - 3.3 Using the iCMM to Support Appraisal
  - 3.4 Using the iCMM in Process Design

Part 2: Model Description
- Chapter 4: Generic Practices
  - Capability Levels - Overview, Sources and Format
  - Capability Level 0 - Incomplete
  - Capability Level 1 - Performed
  - Capability Level 2 - Managed: Planned and Tracked
  - Capability Level 3 - Defined
  - Capability Level 4 - Quantitatively Managed
  - Capability Level 5 - Optimizing
- Chapter 5: Process Areas and Base Practices
  - Process Areas - Overview, Sources, and Format
  - PA 00: Integrated Enterprise Management
  - PA 01: Needs
  - PA 02: Requirements

PA 03: Design
PA 04: Alternatives Analysis
PA 05: Outsourcing
PA 06: Design Implementation
PA 07: Integration
PA 08: Evaluation
PA 09: Deployment, Transition, and Disposal
PA 10: Operation and Support
PA 11: Project Management
PA 12: Supplier Agreement Management
PA 13: Risk Management
PA 14: Integrated Teaming
PA 15: Quality Assurance and Management
PA 16: Configuration Management
PA 17: Information Management
PA 18: Measurement and Analysis
PA 19: *(reserved for future use)*
PA 20: Process Definition
PA 21: Process Improvement
PA 22: Training
PA 23: Innovation

Part 3: Appendices

Appendix A: Change History
Appendix B: Glossary
Appendix C: References
Appendix D: Mapping Tables

Part 1: Overview Information

Chapter 1: Introduction

Chapter 2: Overview of the Model

Chapter 3: Using the Model

Chapter 1: Introduction

Purpose of this chapter

The purpose of this chapter is to introduce the reader to the document and to the FAA-iCMM Project.

In this chapter

The following table provides a guide to the information found in this chapter.

Topic	See Page
1.1 About this Document	1-2
1.2 Background	1-4
1.3 About the FAA-iCMM Project	1-13

1.1 About this Document

Purpose Of This Document	This document presents Version 2.0 of the FAA integrated Capability Maturity Model (iCMM), an integrated capability maturity model for enterprise-wide improvement.
Basic Organization	This document contains five chapters plus appendices, organized into three parts: Part 1: Overview Information Chapter 1: Introduction Chapter 2: Overview of the Model Chapter 3: Using the Model Part 2: Model Description Chapter 4: Generic Practices Chapter 5: Process Areas and Base Practices Part 3: Appendices Change History Glossary References Mapping Tables
Chapter 1: Introduction	Chapter 1 provides the document overview and a brief description of the model, the need it is designed to meet, and how this version was constructed.
Chapter 2: Overview of the Model	Chapter 2 introduces the model, presenting basic concepts that are key to understanding the details and structure of the model. The architecture of the model is presented and the underlying constructs and conventions used in expressing the model are explained.
Chapter 3: Using the Model	Chapter 3 provides information about using the model in different organizational situations and contexts.

1.1 About this Document, continued

Chapter 4: Generic Practices

Chapter 4 contains the generic practices which are grouped by capability level. The generic practices provide guidance for improving the capability of any process.

Chapter 5: Process Areas and Base Practices

Chapter 5 presents the base practices (BP), which characterize practices considered essential to successful enterprise performance. Base practices are grouped into process areas (PA).

Appendices

The appendices include a document/model change history, a change request form, a glossary, references, and mapping tables.

Related Products

In addition to this document, the following work products relate to this model. They are available at www.faa.gov/aio.

Name	Description
FAA-iCMM Appraisal Method (FAM)	A description of the appraisal method developed for use with the iCMM
Training Materials	Materials to facilitate learning about the iCMM and its products
Appendix D Supplement	Detailed mapping tables of FAA-iCMM v2.0 practices to source models, standards, and documents
Others	Numerous related work products and publications

Table 1-1. iCMM Work Products

1.2 Background

What is the FAA-iCMM?

In 1997, the Federal Aviation Administration (FAA) developed the FAA integrated Capability Maturity Model (iCMM) version 1.0 [FAA-iCMM 97] to guide improvement of its engineering, management, and acquisition processes in an integrated, effective, and efficient way. That model integrated three single-discipline CMMs that were being used separately in different FAA directorates: the *Software Acquisition Capability Maturity Model* [SA-CMM 96], the *Capability Maturity Model for Software*, [SW-CMM 93], and *A Systems Engineering Capability Maturity Model* [SE-CMM].

Based on the successful implementation of version 1.0, the FAA has revised and extended the model to come up with this new release, FAA-iCMM v2.0.

Why was Version 1.0 of the iCMM developed?

Several CMMs are relevant to FAA's business. In 1996, before the availability of the iCMM v1.0, the FAA had been dealing with more than one process improvement model at once. Three CMMs in particular were being used in different FAA directorates that work on different aspects of acquisition: the CMMs for software, systems engineering, and software acquisition. These CMMs have different terminologies, different architectures, different improvement goals, different appraisal methods, and cover different aspects of FAA's acquisition business without indicating linkages and interrelationships between their respective disciplines. Although localized improvements had been made using one model, the goal of corporate-wide process improvement remained elusive. Furthermore, as the FAA moved to using integrated product teams representing various disciplines, these teams needed processes that interrelated their work. An integrated reference model would provide better guidance for developing the integrated processes required for a team.

Why was Version 1.0 of the iCMM developed? (continued)

Thus, the iCMM v1.0 was developed to increase the efficiency and the effectiveness of FAA processes and process improvement efforts.

Through implementation of the model, increased efficiency was realized by: reducing the number of process areas (from 52 in the three separate CMMs to 23 in the iCMM); replacing separate, largely redundant efforts to improve similar processes with a single effort to improve an integrated process; and replacing separate appraisals against each CMM with one appraisal against one model.

Increased effectiveness was realized by implementing a single reference model with one architecture, consistent terminology, common process assets, and common improvement goals across disciplines and across the acquisition life cycle; and by coordinating, synergizing, and focusing process improvement efforts with integrated management, engineering, and acquisition guidance suitable for an integrated product team.

Why was Version 2.0 of the iCMM developed?

Version 1.0 is being deployed successfully across much of the agency. Based on experience using the model, changes and enhancements were proposed. Since 1996, newer versions of the original source models have evolved. Furthermore, there are other models and standards of interest to the FAA that also offer guidance for organizational improvement. Stakeholders asked, could these be integrated as well?

Why was Version 2.0 of the iCMM developed? (continued)

The iCMM version 2.0 was developed to address:

- ***Maintenance Change Requests****:* The iCMM v2.0 addresses change requests identified and requested by stakeholders. Typically these resulted in improved clarity in areas that were sometimes misinterpreted or difficult to implement in iCMM v1.0.

- ***Enhancement Change Requests:*** The iCMM v2.0 extends improvement guidance across more business and technical activities that an enterprise performs, such as strategic planning, deployment, and operations.

- ***Currency:*** The iCMM v2.0 updates improvement guidance for the disciplines already included in iCMM v1.0, making the content more current.

- ***One-model concept****:* The iCMM v2.0 integrates several popular organizational improvement approaches into one model to dispel confusion when considering various approaches. One model, the iCMM v2.0, combines the common and best features of them all.

What is the scope of the iCMM?

Version 1.0 of the iCMM focused on systems engineering, software engineering and acquisition practices as integrated from its three source models.

The scope of version 2.0 of the model has broadened to include more of the business and life cycle processes performed across an enterprise.

- ***Enterprise scope**:* The iCMM v2.0 provides best practice guidance on processes used by an enterprise or organization that engages in the acquisition, supply, engineering, development, operation, evolution, support, disposal, and management of products and services.

- ***Discipline scope:*** It integrates software engineering, systems engineering, acquisition, and integrated process and product development (IPPD) disciplines, and includes leadership and strategic processes to assure alignment of projects and activities with enterprise vision, mission, goals, and objectives.

- ***Business focus**:* The iCMM v2.0 integrates best practices from standards for high performing organizations and quality management systems.

- ***Life cycle scope:*** The iCMM v2.0 covers the complete product or service life cycle, from conception through disposal.

The iCMM v2.0 provides best practice guidance for improving these processes and measuring their capability, value, and effectiveness.

What are the sources for iCMM v2.0?

The following standards, models, and documents were integrated into the iCMM v2.0:

- Federal Aviation Administration Integrated Capability Maturity Model (FAA-iCMM) version 1.0, November 1997. [FAA-iCMM 97]
- EIA/IS 731 Systems Engineering Capability, EIA Interim Standard, 1998. [EIA/IS 731]
- ISO 9001:2000, Quality management systems – Requirements. International Organization for Standardization, Third edition, 2000-12-15. [ISO 9001]
- The President's Quality Award Program 2000, United States Office of Personnel Management. [PQA]
- The Malcolm Baldrige National Quality Award Program 2000, United States Department of Commerce, National Institute of Standards and Technology. [MBNQA]
- CMMI for Systems Engineering/Software Engineering/Integrated Product and Process Development, v1.02, CMMI Project, November 2000. [CMMI-SE/SW/IPPD]
- ISO/IEC CD 15288 CD3: System Engineering – System Life Cycle Processes, 9 January 2001. [ISO/IEC CD 15288]
- IEEE/EIA 12207.0-1996 Industry Implementation of International Standard ISO/IEC 12207: 1995 Standard for Information Technology – Software life cycle processes, March 1998. [IEEE/EIA 12207]
- ISO/IEC TR 15504:1998(E) Information technology – Software process assessment – Part 5: An assessment model and indicator guidance, Part 7: Guidelines for software process improvement. [ISO/IEC TR 15504]
- Human Factors Engineering Addendum to the FAA-iCMM v1.0, March 1999. [HFE]
- CMMI for Systems Engineering/Software Engineering/Acquisition (draft), CMMI Project, 2000. [CMMI-SE/SW/A]
- Software Acquisition CMM v1.02 [SA-CMM 99] *(note that [SA-CMM 96] was already included in FAA-iCMM v1.0)*

What are the sources for iCMM v2.0? (continued)

The mapping tables in Appendix D and its supplement show how these various sources were integrated into iCMM v2.0 process areas and practices. All components of these sources are included in the iCMM v2.0 except some areas related to human resource management. (Human resource management is beyond the scope of this iCMM release and may be included in the future.)

Other references were used, including [IPD-CMM], [P-CMM], [EIA-632], [IEEE 1220], [ISO/IEC 15939], and [PSM]. Sources and references are listed in Appendix C.

What are the major differences between v1.0 and v2.0?

Process Areas: There are 23 process areas in iCMM v2.0, just as there were in iCMM v1.0. However, some are new, some are renamed, some are different, and some process areas from v1.0 were integrated into other process areas. All process areas are described in terms of products and services, rather than systems, to clarify the broad applicability of the model.

- *Three new process areas*: These are PA 00 Integrated Enterprise Management, PA 17 Information Management, and PA 10 Operation and Support.
- *One extended process area*: Transition (in v1.0) was extended to include Deployment, Transition, and Disposal (PA 09).
- *Three v1.0 process areas integrated into others*: Peer Review was integrated into PA 08 Evaluation; Prevention was integrated into PA 15 Quality Assurance and Management; Product Evolution was integrated into both PA 23 Innovation, and PA 00 Integrated Enterprise Management.

What are the major differences between v1.0 and v2.0? (continued)

Process Areas (continued):

- *Nine process areas were renamed to better reflect revised content*:

Version 2.0 PA Title	Version 1.0 PA Title
PA 03 Design	PA 03 Architecture
PA 04 Alternatives Analysis	PA 04 Alternatives
PA 06 Design Implementation	PA 06 Software Development and Maintenance
PA 08 Evaluation	PA 08 System Test and Evaluation
PA 12 Supplier Agreement Management	PA 12 Contract Management
PA 14 Integrated Teaming	PA 14 Coordination
PA 18 Measurement and Analysis	PA 18 Measurement
PA 20 Process Definition	PA 20 Organization Process Definition
PA 21 Process Improvement	PA 21 Organization Process Improvement

Base Practices:

- Some content has been rearranged among process areas, and within practices, to improve clarity.
- Some additional practices and practice guidance have been included from integration of additional standards and models.

Staging: The CMM staging (for benchmarking with existing capability maturity models) has been adjusted to reflect current CMM staging. The changes are:

- PA 18 Measurement and Analysis is staged at maturity level 2 (this was at maturity level 4).
- PA 21 Process Improvement is staged at maturity level 3 (this was at maturity level 5).
- PA 01 Needs is staged at maturity level 3 (this was at maturity level 2).
- PA 00 Integrated Enterprise Management is staged at maturity level 3 (this is a new process area).

PA 09 Deployment, Transition, and Disposal is staged at maturity level 2, as was the Transition PA of version 1.0, but the new PA includes deployment and disposal.

What are the major differences between v1.0 and v2.0? (continued)

Capability Levels and Generic Practices: Some practices have been reworded and in addition:

- Capability Level 0 (Incomplete process) was introduced for consistency with other continuous models and standards.
- Capability Level 1: There is one new generic practice: "Identify Work Scope".
- Capability Level 2: There is one new generic practice: "Establish Work Product Requirements".
- Capability Level 3: There is one new generic practice: "Improve Processes"; two previous practices were integrated into others ("Perform Review with Peers" into "Objectively Verify Work Products" at capability level 2; "Coordinate with Affected Groups" into "Coordinate with Stakeholders" at capability level 2).
- Capability Level 4: A single generic practice captures all previous level 4 generic practices.
- Capability Level 5: A single generic practice focuses on pursuing process optimization using statistical process control.

Generic Attributes: This is a new feature in iCMM v2.0. It offers a way of measuring process performance results (usefulness of work products, resource efficiency, and cost effectiveness). It can be used selectively during an appraisal as determined by the appraisal sponsor.

How should the iCMM be used?

The iCMM and the method for applying the model (i.e., appraisal method) are primarily intended to be used by organizations to evaluate their own practices and define improvements to them. The techniques can be used in applying the model for self-improvement only if the users of the model and appraisal methods thoroughly understand the proper application of the model and its inherent limitations. Usage of the iCMM is discussed in Chapter 3.

Who can use the iCMM?

The iCMM can be used by any enterprise or organization that seeks to improve its business performance in an integrated way. Though developed for the FAA, it is designed for use by any organization.

Additional Information

For further information concerning this model, model training, or appraisals using this model contact the FAA-iCMM Project Leader:

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This document is available at the following web sites:
www.faa.gov/aioor www.faa.gov/ipg

1.3 About the iCMM Project

Development of Version 1.0

The FAA-iCMM initiative began in the fall of 1996 with a feasibility study. This study provided an analysis and preliminary merger of the three single-discipline CMMs that had been in use separately in the FAA: the SW-CMM, the SE-CMM, and the SA-CMM. These three CMMs were mapped together at the process area level [Ibrahim, 1996a], and one sample process area was also elaborated at the base practice level [Ibrahim, 1996b]. These efforts demonstrated that it was possible to merge CMMs of different architectures, and that the resultant model significantly reduced the number of process areas and practices while still covering the individual CMM disciplines.

In March 1997, the FAA formed a team of FAA and external CMM and discipline experts and began work on an integrated model that would faithfully and robustly capture all features of its source CMMs. Meanwhile, the Software Engineering Institute (SEI) began developing a Common CMM Framework [CCF], the purpose of which was to provide guidance to multiple CMM users and to assist CMM developers and integrators. The FAA-iCMM project followed those draft guidelines as they continued to evolve in parallel with FAA efforts.

A complete draft of the FAA-iCMM was developed by June 1997 and submitted to the SEI for review. In late September, a joint SEI-FAA review and working session was held to ensure consensus that the FAA's work captured its source CMMs and followed CMM principles, construction guidelines, and requirements as identified in the latest draft CCF documents. In November 1997, the first major integrated capability maturity model, version 1.0 of the FAA-iCMM, was released with the CMM registry mark of the SEI.

Deployment of Version 1.0

Since 1997, version 1.0 of the iCMM has been successfully deployed across much of the Agency (see [Ibrahim 2000]). In addition, organizations outside the FAA have been using the iCMM to guide their integrated process improvement efforts.

The development and deployment of the iCMM v1.0 has provided proof of concept that capability maturity models of varying structures and covering various disciplines can be successfully integrated, and that multidisciplinary organizations can achieve increased efficiency and effectiveness in their process improvement efforts by using an integrated model.

Development of Version 2.0

In the summer of 2000, it was agreed that the iCMM should be updated to incorporate lessons learned from the use of version 1.0, to retain currency with evolving models and standards, to extend improvement guidance across additional business and technical activities, and to integrate additional improvement approaches beyond those in current CMMs. As with the development of version 1.0, a high level mapping table across the 8 major standards and source documents was prepared to demonstrate feasibility. The FAA integrated Process Group (iPG) formed a Configuration Control Board to control the evolution of the iCMM and associated work products, and by November 2000 a team of FAA and external model builders and subject matter experts was formed to develop the next version of the iCMM.

The model was released for extensive internal and external review using a phased approach. Review package one was released in January 2001, containing 12 selected process area descriptions. Reviewer comments were evaluated and incorporated, as appropriate, in review package two, which contained all proposed process area descriptions and was released in March 2001. The last review package had information on staging, capability levels, and generic attributes and was released in May 2001. A 2-day workshop was held with selected key external reviewers in late May 2001, reviewing all aspects of the model. Finally, all practice level mapping tables were reviewed in detail and complete coverage mappings of the source models, at the practice level, were developed to assure robustness, compliance, and detailed traceability.

Development of Version 2.0 (continued)

Approximately 800 internal and external reviewer comments on these packages were received, evaluated, and dispositioned by the author team, and included in the model, as appropriate. The model was then presented to the Configuration Control Board in July 2001 for another review cycle resulting in the approval and publication of version 2.0 of the iCMM in September 2001.

FAA-iCMM Project Composition

Many dedicated people contributed to the development of the iCMM. Project Sponsors counseled the team, helped obtain resources, provided oversight and guidance, and championed the effort by encouraging evolution, acceptance and adoption of the FAA-iCMM.

The Project Leader managed the effort and provided technical direction and support. The Architect determined the structure of the model. Authors created and reviewed work products and provided expertise in areas designated. “Buddies” helped as subject matter experts providing consultation and early review of work products.

“Standards Bearers” took on responsibility for the 8 major source standards and documents, and assured through detailed mapping tables (and extensive discussion) that the respective standards were faithfully and robustly captured in the iCMM v2.0.

Reviewers provided valuable comments on project work products as they evolved through the model development cycle. Included in reviewers are those who submitted change requests regarding version 1.0 of the iCMM. Key external reviewers participated directly in the May workshop, or indirectly by providing detailed comments on the workshop materials distributed for discussion.

The Configuration Control Board supported the project team by evaluating and acting on major iCMM change requests, and establishing the iCMM version 2.0 baseline product.

These contributors to version 2.0 of the iCMM are listed below.

FAA-iCMM v2.0 Project Participants	
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What is the relationship of the iCMM to CMMI?

In the fall of 1997, while version 1.0 of the FAA-iCMM effort was nearing completion, a review of SEI activities was conducted by the U.S. Office of the Under Secretary of Defense for Acquisition and Technology (OUSD), the SEI's sponsor. That review concluded that there was a community need for integrating CMMs [Schaeffer 98]. In early 1998 the Capability Maturity Model Integration (CMMI^{SM}) project was reformulated to move away from creating standards for model builders and users to building integrated models that would meet specific requirements of OUSD. The CMMI project is a collaborative effort among industry, government, and the SEI, sponsored by OUSD and the National Defense Industrial Association (NDIA).

The initial scope of the CMMI project is to integrate software engineering, systems engineering, and integrated product and process development using as source models:

- Systems Engineering Capability Model EIA/IS 731 (interim standard) [EIA/IS 731]
- CMM for Software (Version 2.0 Draft C) [SW-CMM 97]
- Integrated Product Development CMM (draft Version 0.98) [IPD-CMM]

In November 2000, an initial version of the CMMI models integrating these disciplines was released [CMMI-SE/SW/IPPD]. Initial CMMI models are available in both a staged and a continuous representation. A draft acquisition extension was also released [CMMI-SE/SW/A], but this effort is still in the very early stages of development.

The FAA has been extensively involved in the CMMI effort since its inception through participation on the CMMI Steering Group, including providing FAA-iCMM products as reference materials and sharing FAA lessons learned. Similarly, CMMI work products have been used in developing v2.0 of the iCMM and in fact all CMMI practices have been integrated and included as part of v2.0 of the iCMM.

Future Plans

The iCMM will continue to evolve. It is expected that usage of version 2.0 of the model will provide input for updating and validating those new areas that have been introduced. Version 2.0 of the iCMM is pioneering the concept of including practices from models and standards outside the traditional CMM disciplines into a common CMM framework. This new approach will be validated in practice.

Additional extensions have already been proposed for next releases of the iCMM, including enhancements for security, safety, and human resource management. It is expected that these and other new areas will be included in the future.

As its source models and standards evolve, it is planned that the iCMM will evolve as well, to assure currency with community best practice.

As the FAA continues to evolve its integration efforts beyond CMMs, continued collaboration with the CMMI project is anticipated.

The FAA will continue to share the iCMM with other multiple-CMM users and/or organizations interested in improving enterprise-wide processes in an integrated way.

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Chapter 2: Overview of the Model

Purpose of this chapter

The purpose of this chapter is to provide an overview of the concepts and constructs used in the iCMM. It provides a description of the architecture and a section on key concepts and terms that are helpful in understanding the model. It serves as an introduction to the detailed discussion of the model in Chapters 4 and 5.

In this chapter

The following table provides a guide to the information found in this chapter.

Topic	See Page
2.1 Key Concepts and Definitions	2-2
2.2 Architecture Description	2-8
2.3 Capability Dimension	2-13
2.4 Capability Level Summaries	2-20
2.5 Process Dimension	2-22
2.6 Process Area Summaries	2-30
2.7 Maturity Levels and Staging	2-34
2.8 Generic Attributes	2-40

2.1 Key Concepts and Definitions

Introduction

Some terms and concepts introduced in this document have particular meaning within the context of the iCMM. This section elaborates on general concepts that are important to effective understanding, interpretation, and use of the iCMM. Some concepts specific to the model, such as "generic practice" and "base practice," are defined and discussed in the sections of the model description that address them. Other general technical terms are defined directly in the context of their use in the model description, when deemed necessary to assure clarity of interpretation. In general, however, the terminology used throughout the model is intended to be understood by its everyday use or as commonly understood by practitioners. Some definitions, however, are provided in the glossary (Appendix B) in cases where additional clarity might be required.

The concepts discussed in this section are:

- Capability maturity model
- Integrated capability maturity model
- Enterprise
- Organization
- Project
- Senior manager
- Manager
- Project manager
- Customer
- Stakeholder
- Process
- Work Product
- System
- Process capability
- Institutionalization
- Process management
- Process improvement

Capability Maturity Model

A Capability Maturity Model (CMM®) is a reference model that provides guidance for improving organizational performance. CMMs are repositories for best practices that have been shown to be effective through widespread use in government and industry. Organizational performance can be measured and improved by comparing actual practice to essential practices contained in CMMs.

Capability Maturity Model (continued)

A CMM describes the key elements of an effective process for a given discipline. It also describes stages through which processes progress as they are defined, implemented, measured, and improved from an ad hoc, immature process to a disciplined, mature process with improved quality and effectiveness.

Associated with a CMM are one or more appraisal methods that help determine current process capability and/or define the most critical issues for improved quality and process effectiveness.

Thus, a CMM is used to appraise the existence and institutionalization of a process that implements referenced practices. CMM-adopting organizations report significant increases in staff morale, ability to meet schedule, productivity, product quality, and customer satisfaction.

Integrated Capability Maturity Model

The original CMMs were developed to improve performance within a single discipline, such as software engineering or systems engineering or software acquisition. Although many best practices are generic by nature, in single-discipline models they are organized and expressed to focus guidance within a single-discipline view. An integrated CMM captures the guidance of single-discipline CMMs, relates the disciplines, removes redundancy, and integrates best practices into a common reference model with a common structure and common terminology. An integrated CMM can be used by multiple disciplines. Process improvement efforts can then be aligned across a multi-disciplinary enterprise.

Version 1.0 of the iCMM, released in 1997, was the first major integrated capability maturity model, integrating and capturing all principles, features, and practices in the CMMs for systems engineering, software engineering, and software acquisition. Through widespread use in the FAA, version 1.0 of the iCMM demonstrated that using an integrated CMM increases the effectiveness and efficiency of processes and process improvement efforts for multi-disciplinary organizations.

Version 2.0 of the iCMM continues the integration concept by integrating additional models and standards into a common framework for integrated enterprise improvement.

Enterprise	An enterprise is one or more organizations with a set of goals and objectives to offer products and services. The enterprise encompasses units that contribute to the enterprise mission, goals, and objectives.
Organization	An organization is 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.
Project	A project is an undertaking that develops and/or maintains one or more products or provides a service. A project typically has its own funding, cost accounting, and schedule. It may be structured as a team, task force, or other entity used by the organization to produce products or provide services to a customer. Projects may be called by various names in different organizational contexts, such as product teams, service teams, business units, management units, or programs.

Senior Manager	A senior manager is at a high enough level in an organization or enterprise that the primary focus of the person filling the role is the long-term vitality, viability, and success of the organization, rather than short-term project and contractual concerns. A senior manager has authority to direct resource allocation or reallocation in support of process improvement.
Manager	A manager provides technical and administrative direction and control to those performing tasks or activities within the manager's area or responsibility. Traditional functions of a manager include planning, organizing, directing, and controlling work within an area of responsibility.
Project Manager	A project manager is responsible for an entire project and for planning, directing, controlling, structuring, and motivating the project. The project manager is ultimately responsible to the customer.
Customer	A customer is an individual or entity for whom a product is developed or service is rendered, and/or an individual or entity who uses the product or service. A customer may be external or internal to the organization or may be represented by a surrogate, such as a marketing or focus group. In most cases, the term customer is used in the singular, as a grammatical convenience. However, this does not preclude the case of multiple customers.
Stakeholder	A stakeholder is a group or individual that is affected by or in some way accountable for the outcome of an undertaking. A stakeholder may have a right, share or claim in a product or service, and would be interested that it meet that party's needs and/or expectations. Stakeholders can include customers, project members, suppliers, operators, maintainers, and others. A "relevant stakeholder" designates a group or individual that is called out in a plan to perform certain types of activities or to receive certain kinds of information.

Process

A process is a set of activities performed to achieve a given purpose. Activities may be performed iteratively, recursively, and/or concurrently. Some activities may transform input work products into output work products needed for other activities. The allowable sequence for performing activities is constrained by the availability of input work products and resources, and by management control. Several types of processes are defined in the iCMM, such as a "performed" process and a "managed" process. These are defined in the description of the capability dimension of the model.

Work Product

A work product is any output or service that is generated or that results from performing a process. These work products can include, for example, files, documents, services, specifications, or processes such as a training process or a disposal process. Some work products may be delivered to a customer (these are sometimes simply called "products"). Others may be parts of another work product.

Even though the definition of work product includes services, in the iCMM the phrase "work products and services" or "products and services" is sometimes used to emphasize the inclusion of services.

When describing practices, the iCMM includes "typical work products" to elaborate further the intended scope of a practice. These lists are illustrative only and reflect a range of organizational and product contexts to aid in understanding the practice. They are not to be construed as mandatory work products.

System

A system is a set of interacting or interrelated elements (e.g. people, products, services, processes, hardware, software, facilities) organized to achieve one or more stated purposes, or to provide a capability to satisfy a stated need or objective. A system may be considered as a product and/or a service it provides.

In most cases, the iCMM uses the phrase "products and/or services" instead of "system" to denote this concept.

Process capability	Process capability is the quantifiable range of expected results that can be achieved by following a process. The capability of an organization's process helps to predict the ability of a project to meet goals. Projects in low capability organizations experience wide variations in achieving cost, schedule, functionality, and quality targets.
Institution-alization	Institutionalization is the building of infrastructure and corporate culture that supports methods, practices, and procedures, so that they are the ongoing way of doing business even after those who originally defined them are gone. Institutionalization implies that the breadth and depth of the implementation of a process and the length of time a process has been in place are appropriate to ensure that the process is an ingrained part of the way the work is performed.
Process management	Process management is the set of activities, methods, tools, and infrastructures used to define, implement, monitor, predict, evaluate, control, and improve the performance of a process. The focus on process management implies that a project or organization accounts for both product- and process-related factors in business planning, performance, evaluation, monitoring, and corrective action.
Process improvement	Process improvement is the set of actions taken to change processes so that they meet business needs and achieve business goals more effectively. Process improvement includes both the actions designed to improve the performance and maturity of processes, and the results of such actions.

2.2 Architecture Description

Introduction

Organizational improvement models may be structured or represented in a variety of ways. Capability models are typically developed using either a staged representation (where certain established sets of process areas must be improved before others) or a continuous representation (where all process areas are of equal priority, can be improved to any capability level, and the organization chooses the order of improvement). Other models or standards provide best practices for performing a process, but do not provide practices for systematic improvement.

Some of the source models for the iCMM are staged ([SA-CMM 96], [SA-CMM 99], [CMMI-SE/SW/IPPD] (staged), [CMMI-SE/SW/A] (staged)); some are continuous ([EIA/IS 731], [ISO/IEC TR 15504], [CMMI-SE/SW/IPPD] (continuous), [CMMI-SE/SW/A] (continuous)); others follow neither of these structures ([ISO 9001], [PQA], [MBNQA], [IEEE/EIA 12207], [ISO/IEC CD 15288]).

The iCMM has structured the best practice guidance from its various source models and standards into an architecture that offers the most flexibility for organizations pursuing process improvement. This architecture is called the "continuous with staging" representation.

Continuous

A continuous representation separates specific process performance guidance from generic process improvement guidance related to increasing the capability of any process. Identical capability levels are defined to guide improvement of processes associated with any process area. The organization decides the priority and ordering of processes to improve based on business objectives, and it sets its own target capability levels for the processes selected. The iCMM is structured to provide these features of a continuous representation.

Staging

Staging, the groupings of process areas and generic practices into maturity levels, is also provided with the iCMM. This provides guidance regarding the ordering of processes to improve, if needed. Staging also enables a summarized maturity level to be determined, if desired. By defining maturity levels in the iCMM that are at least equivalent to maturity levels in the source models, iCMM users can benchmark progress with respect to users of other models that have defined maturity levels. However, the iCMM is not structured to require a specific ordering of process areas for improvement.

Architecture overview

Figure 2.1 shows the general structure of the iCMM.

Following the continuous representation, the iCMM is structured in two parts—the process dimension and the capability dimension. Descriptions of the process dimension and the capability dimension follow the figure.

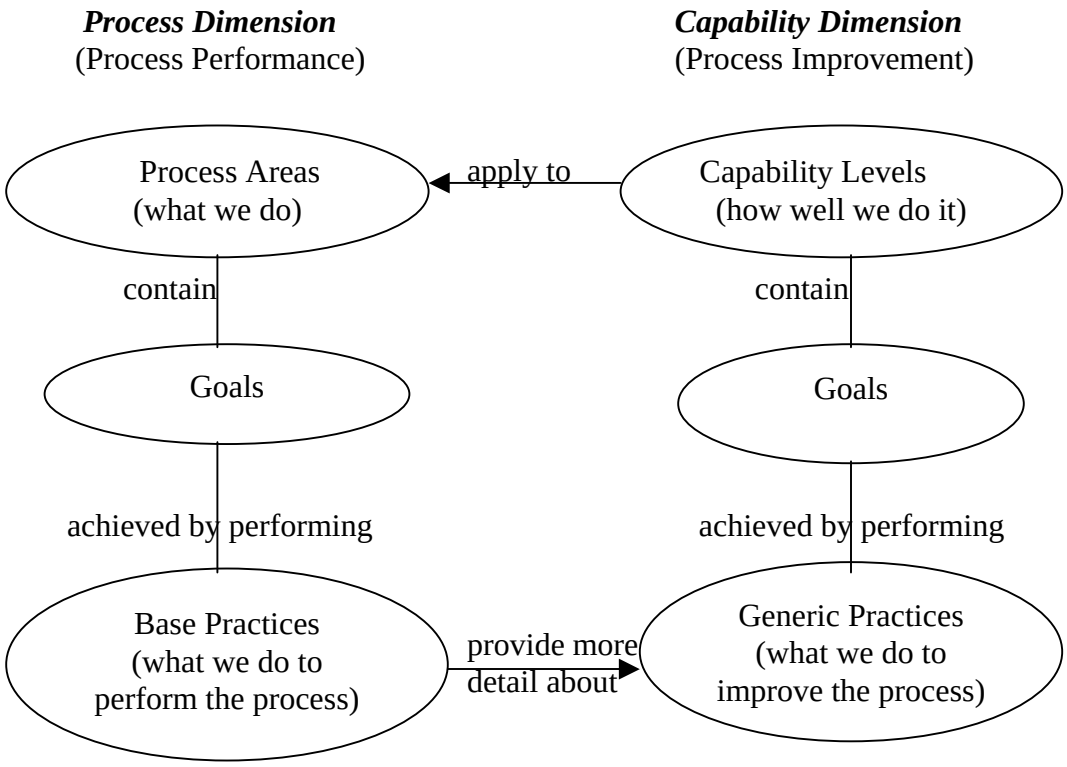

Figure 2.1 Process Performance and Process Improvement

Process Dimension

The process dimension focuses on process *performance*. It consists of base practices that are specific to the performance of management, life cycle, and support processes across an enterprise. These practices provide guidance regarding *what we do*.

The iCMM uses process areas to describe the process dimension. Process areas group together base practices related to achieving goals and a common purpose.

The process dimension is summarized later in this chapter (see sections 2.5 and 2.6) and discussed in detail in Chapter 5.

Capability Dimension

The capability dimension focuses on process *improvement*. It consists of generic practices that are related to overall process management and institutionalization. These practices provide guidance regarding *how well we do it*.

The iCMM uses capability levels, goals, and generic practices to describe process capability:

- Capability levels indicate increasing levels of ability to perform, control and improve processes associated with process areas.
- Generic practices are staged and organized by capability levels. They can apply to any process area.

The capability dimension is summarized later in this chapter (see sections 2.3 and 2.4) and discussed in detail in Chapter 4.

Relating the Process and Capability Dimensions

The generic practices in the capability dimension are applied to process areas in the process dimension to determine process capability. Some generic practices, however, depend on a process area to perform that practice. In these cases, the process area supports that practice and provides more detailed guidance for performing the generic practice; the related generic practice focuses on deploying these practices in relation to individual process areas.

For example, the generic practice 2.9 Manage Work Products states "Place identified work products of the process under appropriate levels of configuration management." This practice depends on the process area PA 16 Configuration Management to perform that practice and more detailed guidance for performing the Manage Work Products generic practice is found in that process area. The generic practice focuses on assuring that configuration management practices are deployed in relation to work products of any process that is being improved.

When selecting process areas and capability levels for improvement targets, it is important to pay attention to the dependencies between generic practices and process areas. When a generic practice is dependent upon a certain process area, either to perform the generic practice or to provide a prerequisite product, the generic practice will be ineffective if the process area is not implemented.

Relationships of generic practices to supporting process areas are pointed out in the description of each generic practice in Chapter 4.

Note that since the generic practices are applied to all process areas, they are also applied to the process areas that support them. For example, the Manage Work Products generic practice should be used to manage work products (such as a list of configuration items) that result from a configuration management process.

Staging and Maturity Levels

Staging is an ordering of practices or process areas. The generic practices are staged or organized into capability levels. Similarly, the process areas are staged or organized into maturity levels. Thus, in the iCMM, the concept of staging is reflected in two ways: the capability levels apply the concept to a single process area; and maturity levels can be defined to provide a roadmap for suggested implementation of the process areas in the model (e.g., "what to focus on next"). In the latter case, maturity level is simply a conceptual grouping of process areas that are staged, and defined as belonging to that maturity level.

Maturity levels are a way of defining characteristics of the evolution of organizations as they improve. However, maturity levels are not a separate structure in the iCMM; rather they are a way of ordering the components of the process and capability dimensions of the model. Each level is considered to provide a foundation for the next increment of improvement in the level that follows.

Staging and maturity levels are discussed later in this chapter (see section 2.7).

Appraisal

An appraisal is a comparison of processes being practiced to a reference model or standard, in this case to the iCMM. An appraisal determines an organization's capability to perform a process area. In practice, this entails reviewing the organization's implementation of base and generic practices and its achievement of the associated goals through a capability level. For example, to achieve capability level 2 for a process area, the organization's activities are reviewed against the base and generic practices and goals through capability level 2. The process area and capability level goals through capability level 2 must be satisfied.

Appraisals are used to understand process capability in order to improve processes. Appraisals can also be used to evaluate process effectiveness by means of Generic Attributes (see section 2.8).

Appraisals and process improvement are described in Chapter 3.

2.3 Capability Dimension

Introduction

The capability dimension of the iCMM measures how well an organization performs its processes. It gathers together best practices from the various iCMM source models and standards to provide integrated process improvement guidance.

The iCMM characterizes its capability dimension using capability levels, goals, and generic practices.

A *capability level* is a set of practices that work together to provide a major enhancement in the capability to perform a process, and a *generic practice* is a practice that enhances the capability to perform **any** process. Each capability level has a *goal* that summarizes an observable, expected state to be achieved if practices mapped to that goal are performed. The generic practices are grouped by capability level; all generic practices at a level contribute to the achievement of the goal at that level and map to that goal.

Generic practices are additive and build upon each other, i.e., none of the practices "go away" as you move up the capability levels. Generic practices help determine how well a process area is managed and improved as a whole.

Why group generic practices by capability level?

The ordering of the generic practices is based on the observation that some practices benefit from the presence of others. Before an organization can define, tailor, and use a process effectively, individual projects should have some experience managing the performance of that process. Before institutionalizing a specific estimation process for an entire organization, for example, an organization should first attempt to use the estimation process on a project. However, some practices should be considered together (not one ordered before the other) since they work together toward enhancing capability. For example, planning a process and measuring process performance against the plan should be considered together.

Why group generic practices by capability level? (continued)

Capability levels are important both in performing an appraisal and in improving an organization's process capability. In the case of an appraisal where an organization has some, but not all, generic practices implemented at a particular capability level for a particular process, the organization usually is operating at the lowest completed capability level for that process. In order for an organization to reap the full benefit of implementing a generic practice, all generic practices at lower capability levels should be in place.

In the case of improvement, organizing the generic practices into capability levels provides an organization with an "improvement road map" to enhance its capability for a specific process.

An appraisal should be performed to determine the capability level for each relevant process area. Different process areas can, and probably will, exist at different levels of capability. The organization will be able to use this process-specific information to focus improvements to its processes. The priority and sequence of the organization's activities to improve its processes should take into account its business goals.

Capability Levels	The iCMM has six levels of process capability that can be applied to any process area. Each of these levels is summarized below. The next section of this chapter (section 2.4) summarizes capability level goals and generic practices. A full description of the capability dimension is provided in Chapter 4.
Level 0: Incomplete	An incomplete process is either not performed or partially performed. One or more of the goals of the process area are not achieved. The process is not implemented.
Level 1: Performed	A performed process is a process that achieves the goals of the process area. Base practices of the process area are generally performed. At this level, all base practices are generally performed somewhere in the project's or organization's implemented process, but processes are characterized as ad hoc and even occasionally chaotic. Consistent planning and tracking of performance are missing. Good performance, therefore, depends on individual knowledge and effort. Work products are generally adequate, but quality and efficiency of production depend on how well individuals within the organization perceive that tasks should be performed. Based on experience, there is general assurance that an action will be performed adequately when required. However, the capability to perform an activity is not generally repeatable or transferable. The main distinction between an incomplete process and a performed process is that a performed process achieves all of the goals of the process area.

Level 2:

Managed Planned & Tracked

A managed process is a performed (capability level 1) process that is also planned and tracked. The process is managed to ensure its institutionalization, and to ensure the achievement of specific objectives for the process, such as customer satisfaction, cost, schedule, and quality objectives.

Those responsible for performing the process establish objectives considering their business context. Objectives are determined based on an understanding of what will satisfy the relevant stakeholders. Objectives may be quantitative or qualitative. They may be specific to the individual process or they may be defined at a higher level or for a group of processes, with the individual processes contributing to achieving these objectives. Objectives may be revised as part of corrective actions taken for the process.

At capability level 2, management is assured that: the process is being performed; process performance is planned, tracked, measured, reviewed, verified, and predictable; policy is followed; corrective action is taken. Practitioners are assured that: they have adequate skills; responsibilities are clear; resources are adequate; work products are managed; the process is understood. Customers are assured that requirements and standards for work products and services are defined and documented, and that work products and services satisfy their specified requirements and standards. For all involved in the process, commitments are established, understood, honored, and revised as necessary.

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

The primary distinction between a performed process and a managed (planned and tracked) process is the extent to which a process is managed. A managed process is planned and the performance of the process is tracked against the plan. Corrective actions are taken when the actual results and performance deviate from the plan. A managed (planned and tracked) process achieves the objectives of the plan and is institutionalized for consistent performance. Institutionalization is accomplished by performing the generic practices.

Level 3: Defined

A defined process is a managed, planned and tracked (capability level 2) 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.

The organization's set of standard processes, which forms the basis of the defined process, is established to meet specific business objectives for the organization. The standard processes implement the base practices and support the performance of a managed (planned and tracked) process. These processes are established based on experience captured using previous and current processes.

Data and experiences from using the defined process are gathered and used to determine if change is needed. Accordingly, both the set of standard processes and the defined processes are improved.

A critical distinction between a managed process and a defined process is the scope of application of the standards, process descriptions, and procedures. For a managed process, the standards, process descriptions, and procedures may be in use in only a specific instance of the process (e.g., on a particular project). Because the standards, process descriptions, and procedures are tailored from the organization's set of standard processes and related organizational process assets, the defined processes that are performed across the organization are appropriately consistent. The capability to perform a defined process is directly transferable to new projects within the organization.

Another critical distinction is that a defined process is described in more detail and performed more rigorously than a managed process. Management of the defined process is based on the additional insight provided by an understanding of the interrelationships of the process activities and detailed measures of the process, its work products, and its services.

A defined process is tailored from an organizational standard process and clearly states the following: purpose, inputs, entry criteria, activities, roles, measures, verification steps, outputs, exit criteria.

Level 4: Quantitatively Managed

A quantitatively managed process is a defined (capability level 3) process that is controlled using statistical and other quantitative techniques. Quantitative objectives for process performance are used in managing process performance. The capability of the process, in terms of the range of expected performance results for selected attributes, is understood statistically. The defined process has been stabilized by eliminating special causes of process variation. Expected performance is within defined control limits. The ability of the process to achieve quantitative performance objectives is understood.

Processes that are significant contributors to overall process performance objectives are selected, and relevant measures are identified based on the standard set of organizational processes. Projects tailor the standard process (as in capability level 3) and establish the defined process. Additionally, however, projects select particular processes (or subprocesses) that are relevant to the established measures, and stabilize them by bringing them under statistical process control.

Measures and results from statistically controlled processes are stored in an organizational repository, aggregated, and analyzed to derive a quantitative understanding of the capability of the set of organizational standard processes, in relation to selected objectives and measures.

A main distinction between a defined process and a quantitatively managed process is the predictability of the process performance. With a quantitatively managed process, the process has been stabilized and future performance of the process can be predicted quantitatively. A defined process may only provide qualitative predictability. Note that the quantitatively managed process is driven by statistically controlling only those particular processes that are key to meeting established business objectives.

Level 5: Optimizing

An optimizing process is a quantitatively managed (capability level 4) process that is changed and adapted to meet relevant current and projected business objectives.

Optimizing performance is enabled by quantitative feedback from the process and from piloting innovative ideas and technologies. A focus on widespread, continuous improvement permeates the organization. The organization establishes quantitative performance goals for process effectiveness and efficiency based on its business goals.

Improvements focus on introducing changes to those processes that are now under statistical control. These changes try to shift the expected (mean) performance value by removing common causes of process variation, or introducing new technology. Performance is optimizing as the organization strives to meet ever-stretching target levels set by the organization for performance excellence.

This is the highest achievement level from the viewpoint of process capability. The organization has established quantitative, as well as qualitative, goals for process effectiveness and efficiency, based on long-range business strategies and goals. Continuous process improvement toward achievement of these goals using timely, quantitative performance feedback has been established. Further enhancements are achieved by pilot testing of innovative ideas and planned insertion of new technology.

2.4 Capability Level Summaries

Goals and Generic Practices	This section summarizes the capability levels by presenting their goals and the titles of their generic practices. Full generic practice statements and descriptions are provided in Chapter 4.
Level 0: Incomplete	There is no goal and there are no generic practices at this level.
Level 1: Performed	Goal: The process achieves the goals of the process area. Generic Practices: 1.1 Identify Work Scope 1.2 Perform the process
Level 2: Managed: Planned & Tracked	Goal: The process is institutionalized as a managed (planned and tracked) process. Generic Practices: 2.1 Establish organizational policy 2.2 Document the process 2.3 Plan the process 2.4 Provide adequate resources 2.5 Assign responsibility 2.6 Ensure skill and knowledge 2.7 Establish work product requirements 2.8 Consistently use and manage the process 2.9 Manage work products 2.10 Objectively assess process compliance 2.11 Objectively verify work products 2.12 Measure process performance 2.13 Review performance with higher-level management 2.14 Take corrective action 2.15 Coordinate with participants and stakeholders

Level 3: Defined	Goal: The process is institutionalized as a defined process. Generic Practices 3.1 Standardize the process 3.2 Establish and use a defined process 3.3 Improve processes
Level 4: Quantitatively Managed	Goal: The process is institutionalized as a quantitatively managed process. Generic practice: 4.1 Stabilize process performance
Level 5: Optimizing	Goal: The process is institutionalized as an optimizing process. Generic practice: 5.1 Pursue process optimization

2.5 Process Dimension

Introduction

The process dimension of the iCMM describes what an organization does (i.e., the functions it carries out), as distinct from how disciplined it is in doing it. It gathers together best practices from the various iCMM source models and standards to provide integrated process performance guidance.

The iCMM characterizes its process dimension using categories, process areas, goals, and base practices.

A *category* is a group of process areas addressing the same general type or area of activity.

A *process area* (PA) is a group of related base practices that are essential for achieving the purpose of the PA.

A *base practice* summarizes a fundamental essential characteristic of performing a process that meets the purpose of the PA. Base practices are mapped to *goals.*

Process area *goal*s summarize an observable, expected state to be achieved if the practices mapped to them are performed. Goals are expected to be achieved if the purpose of the PA is met, and the process area is successfully implemented.

The Categories and Process Areas

There are three process categories and 23 process areas in the iCMM:

- Management Processes - This category contains 5 process areas
- Life Cycle Processes - This category contains 8 process areas
- Support Processes - This category contains 10 process areas

The process areas are shown in the following diagram.

Management Processes

Integrated Enterprise Management
Project Management
Risk Management Supplier Agreement Management Integrated Teaming

Life Cycle Processes

Needs
Requirements Design Integration Deployment, Transition, Disposal Design Implementation Operation and Support
Evaluation

Support Processes

Outsourcing	Alternatives Analysis	Measurement and Analysis	
Quality Assurance And Management	Configuration Management	Information Management	
Process Definition	Process Improvement	Training	Innovation

Management Processes

The management processes are used to set vision, goals, strategy, and direction. Management processes initiate, align, plan and track activities that will accomplish the objectives of the enterprise, organization, project, or team. They oversee the execution of the other processes in the model.

The process areas in this category are:

- PA 00 Integrated Enterprise Management
- PA 11 Project Management
- PA 12 Supplier Agreement Management
- PA 13 Risk Management
- PA 14 Integrated Teaming

Life Cycle Processes

The life cycle processes are used to develop, maintain, transition, and operate a product or service in order to provide and sustain the services that a customer or stakeholder needs. These processes cover the typical life cycle of a product or service.

The process areas in this category are:

- PA 01 Needs
- PA 02 Requirements
- PA 03 Design
- PA 06 Design Implementation
- PA 07 Integration
- PA 08 Evaluation
- PA 09 Deployment, Transition, and Disposal
- PA 10 Operation and Support

Support Processes

The support processes are used by other process areas when needed and contribute to the success and quality of all the processes.

The process areas in this category are:

- PA 04 Alternatives Analysis
- PA 05 Outsourcing
- PA 15 Quality Assurance and Management
- PA 16 Configuration Management
- PA 17 Information Management
- PA 18 Measurement and Analysis
- PA 20 Process Definition
- PA 21 Process Improvement
- PA 22 Training
- PA 23 Innovation

Relationships among Process Areas

Although the process areas are grouped into categories, and described separately, there are many interactions and relationships among them. These relationships are explained as part of each process area description in Chapter 5.

Process Area Scope

Version 1.0 of the iCMM integrated three CMMs and provided integrated process areas pertaining to systems engineering, system/software acquisition, and software engineering.

Version 2.0 of the iCMM integrates several additional models and standards (listed on the next page), extending its scope of integrated process areas to cover processes used by an enterprise or organization that engages in the acquisition, supply, engineering, development, operation, evolution, support, and management of products and services across the product or service life cycle.

Integrated Process Areas and Practices

In the iCMM, the process areas and their base practices are integrated. Dimensions of an integrated process may include its applicability across disciplines, across life cycle phases, and across the breadth and depth of an organization.

- **Multidisciplinary:** An integrated process may require participation of experts from more than one functional area or discipline. Examples include a requirements engineering process for a software-intensive system that involves systems engineers and software engineers; an acquisition management process that involves acquisition program managers and technical project managers; and an outsourcing process that involves procurement experts, legal experts, and engineers.

- **Supportive:** An integrated process may support multiple disciplines. Examples include a configuration management process that supports management of software items, hardware items, contract deliverables, documents of any sort; a quality assurance process that assures quality of any types of processes and products; and a training management process that manages learning opportunities for professionals engaged in any discipline.

Integrated Process Areas and Practices (continued)

- **Full Life Cycle**: An integrated process may require participation of experts across phases and across the full life cycle. Examples include: a transition process from development to maintenance; a deployment process from development to operations; a customer focus process or a requirements management process that is performed continuously across all life cycle phases.

  General engineering terminology is used in life cycle process areas so that any technical discipline involved can use them for process improvement.

- **Organizational Applicability**: An integrated process may apply across core business areas and at multiple organizational levels. Examples include: leadership, strategic planning, and investment management across an enterprise; management applied to an enterprise, a division, a program, a project, or a task.

  Usage contexts and organizational applicability are discussed in Chapter 3.

iCMM Process Area Sources

The iCMM v2.0 incorporates material from the latest versions of standards and models that deal with:

- *Organizational excellence*: [PQA], [MBNQA]
- *Quality management*: [ISO 9001], [ISO 9004]
- *Systems engineering*: [EIA/IS 731], [ISO/IEC CD 15288], [EIA-632], [CMMI – SE/SW/IPPD]
- *Software engineering*: [ISO/IEC TR 15504], [IEEE/EIA 12207], [CMMI – SE/SW/IPPD]
- *Acquisition*: [SA-CMM 99], [CMMI – SE/SW/A]
- *Integrated product development*: [CMMI – SE/SW/IPPD], [IPD-CMM]

Of course the baseline model for developing iCMM v2.0 is iCMM v1.0 which already includes:

- *Systems engineering*: [SE-CMM]
- *Software engineering*: [SW-CMM 93]
- *Acquisition:* [SA-CMM 96]

Thus the iCMM v2.0 brings together guidance from all of these different models and standards.

Process Area Mapping

Mapping tables of high level practice groupings in the source documents (e.g., process areas, focus areas, subclauses, categories, processes, etc. depending on terminology used in the particular source) were created to guide the development of the iCMM. These tables mapped source components based on their commonality of purpose. From these high level mapping tables, process areas for the iCMM were selected.

Process Area Characteristics

The following criteria were used to integrate and derive the iCMM process areas:

- Process areas should assemble related activities in one area for ease of use.
- Process areas should be implementable in multiple organization and product contexts.
- Process areas are generally improvable as a distinct process.
- Process areas are generally improvable by a group with similar interests in the process.
- Process areas include all base practices that are required to meet the goals of the process area.

The process area-level mapping tables are provided in Appendix D.

Note that all components of the source models are included in iCMM v2.0 except some areas related to human resource management. These aspects may be included in future versions as the iCMM continues to evolve.

Base Practice Selection

Once major components of the source models and standards had been aligned, mapping was continued at the practice level. In some cases, practices within a given source component mapped to more than one iCMM process area, or to more than one base practice within a process area, or to generic practices rather than base practices. This was partially due to the varying levels of granularity of practice guidance in the sources.

In general, base practices summarize essential characteristics of performing a process. Where sources contained further guidance amplifying essential practice, this information is included in the base practice descriptions in sections providing notes and additional practice guidance.

The following criteria were additionally used for base practices:

- Overlap between the base practices should be minimized.
- Base practices should be applicable using multiple methods in multiple business contexts. They should not specify a particular method or tool.
- Results of a base practice should be objectively observable using reasonable means for investigation (e.g., interviews, document review).

Detailed mappings at the practice level are provided in a separate supplement to Appendix D.

2.6 Process Area Summaries

The Process Areas and their Purposes

The process areas and their purpose statements are presented below to summarize the process dimension of the model. Full process area descriptions are provided in Chapter 5.

Management Processes

The five management processes are used to set vision, goals, strategy, and direction. Management processes initiate, align, plan and track activities that will accomplish the objectives of the enterprise, organization, project, or team. They oversee the execution of the other processes in the model.

- **PA 00: Integrated Enterprise Management:** The purpose of Integrated Enterprise Management is to establish the vision, mission, values, goals, and objectives of the enterprise; establish and maintain strategic plans to accomplish goals and objectives; initiate and monitor projects/activities to advance the business of the enterprise; evaluate performance relative to goals and needs; and enable individuals to function effectively by sharing a common understanding of enterprise vision, culture, and goals.

- **PA 11: Project Management:** The purpose of Project Management is to ensure the project achieves its objectives, by planning, directing, tracking, and controlling the activities necessary for development and delivery of required products and services.

- **PA 12: Supplier Agreement Management:** The purpose of Supplier Agreement Management is to ensure that the activities described in agreements are being performed, and that evolving products and services will satisfy requirements described in agreements.

- **PA 13: Risk Management:** The purpose of Risk Management is to identify and analyze risks to the achievement of project objectives and execute plans that reduce the likelihood and/or consequence of risks that meet mitigation criteria.

Management Processes (continued)

- **PA 14: Integrated Teaming:** The purpose of Integrated Teaming is to identify and maintain the disciplines and stakeholders necessary to effectively accomplish appropriate multidisciplinary/cross-functional missions, to create integrated teams as appropriate, and to establish and maintain a supportive teaming environment.

Life Cycle Processes

The eight life cycle processes are used to develop, maintain, transition, and operate a product or service in order to provide and sustain the services that a customer or stakeholder needs. These processes cover the typical life cycle of a product or service.

- **PA 01: Needs:** The purpose of Needs is to elicit, analyze, clarify, and document evolving customer and other stakeholder needs and expectations, and to establish and maintain communication with the customer and other stakeholders throughout the life cycle to assure a continuous understanding of what will satisfy those needs.

- **PA 02: Requirements:** The purpose of Requirements is to develop requirements that meet the customer's need; analyze the product, service and other requirements; derive a detailed and precise set of requirements; and manage those requirements throughout the life cycle.

- **PA 03: Design:** The purpose of Design is to establish and maintain an architecture and design solution for the needs and requirements of the customer and other stakeholders.

- **PA 06: Design Implementation:** The purpose of Design Implementation is to produce a specified solution component.

- **PA 07: Integration:** The purpose of Integration is to ensure that product and service elements will function as a whole.

Life Cycle Processes (continued)

- **PA 08: Evaluation:** The purpose of Evaluation is to confirm that developed and acquired products and services satisfy specified requirements and operational needs, and identify and document actual and potential defects in evolving product and service elements.

- **PA 09: Deployment, Transition, and Disposal:** The purpose of Deployment, Transition and Disposal is to: place a product or service into an operational environment, transfer it to the customer/stakeholder, and support organization, and deactivate and dispose of the replaced product and /or dispense with the service.

- **PA 10: Operation and Support:** The purpose of Operation and Support is to operate the product, system or service, support its users, monitor and sustain its performance, and take or initiate corrective action as required.

Support Processes

The ten support processes are used by other process areas when needed and contribute to the success and quality of all the processes.

- **PA 04: Alternatives Analysis:** The purpose of Alternatives Analysis is to apply structured analysis and decision-making to selected issues and communicate the results to stakeholders.

- **PA 05: Outsourcing:** The purpose of Outsourcing is to identify the portions of the solution and support structure that are to be provided from outside the organization, identify potential sources, and select the supplier for the needed capability.

- **PA 15: Quality Assurance and Management:** The purpose of Quality Assurance and Management is to ensure the quality of the product or service, ensure the quality of the processes used to create or provide the product or service, and provide management with appropriate visibility into the processes and product.

Support Processes (continued)

- **PA 16: Configuration Management:** The purpose of Configuration Management is to establish and maintain data on and status of identified configuration items, analyze and control changes to the identified items, and to establish and maintain the integrity between the identified work products and their data throughout the project's life cycle.

- **PA 17: Information Management** The purpose of Information Management is to make relevant and timely information available to those who need it during and after the lifetime of products and services.

- **PA 18: Measurement and Analysis** The purpose of Measurement and Analysis is to collect and analyze data related to processes and resulting products and services to provide quantitative insight into performance relative to goals.

- **PA 20: Process Definition** The purpose of Process Definition is to define and maintain a standard set of process assets that support organizational learning and improve process performance.

- **PA 21: Process Improvement** The purpose of Process Improvement is to continuously improve the effectiveness and efficiency of the project and/or organization's processes so that its business is conducted more efficiently and effectively.

- **PA 22: Training** The purpose of Training is to develop and maintain the skills and knowledge of people so they perform their roles effectively and efficiently.

- **PA 23: Innovation** The purpose of Innovation is to identify, select, and introduce selected technology improvements into products, processes, and the work environment to improve the organization's business results.

2.7 Maturity Levels and Staging

Staging in the iCMM

Staging is a grouping of process areas and capability levels that can be used by an organization to guide process improvement. The choice of process area and capability level improvement targets is always based on the business objectives of the implementing organization. However, staging provides guidance on what process areas might be pursued together, or which process areas might be pursued first or next.

Staging groups process areas into a series of maturity levels or evolutionary plateaus. In general, the group of process areas at one maturity level is considered to be an essential foundation for the maturity level that follows.

Maturity levels also permit benchmarking with existing capability maturity models or with other parts of the organization. They can provide a summary rating of an organization's process maturity.

The staging that is described below is designed to be used for benchmarking with existing CMMs (see also Alternative Stagings later in this section).

Maturity Levels and Capability Levels

The same concepts apply to process capability levels and organizational maturity levels, but in one case individual process capability is measured and in the other, the capability levels of selected groups of process areas are measured. Either a project or an organization can achieve either capability levels or maturity levels. That is determined by the scope of the appraisal performed to determine ratings (see Chapter 3).

Maturity Levels for Equivalency and Benchmarking

Not all of the models and standards that are integrated in the iCMM use maturity levels. This section describes maturity levels in the iCMM for benchmarking with the source models that do have this concept. The staging below is at least equivalent to comparable levels in the source CMMs that have maturity levels defined (i.e., [SA-CMM 99], and [CMMI-SE/SW/IPPD] (staged)). In other words, achieving a given maturity level on the iCMM is at least equivalent to achieving that maturity level on the SA-CMM or the CMMI model.

Allocation of process areas to maturity levels was made using the following guidelines:

- Process areas that explain generic practices at that level. These process areas are essential to institutionalizing the process at that level.
- Process areas that resulted from integrating process areas staged at that level in source CMMs. When the source models differed in their stagings of these process areas, the lower maturity level placement was selected for the iCMM.
- Other process areas deemed essential to establishing and sustaining organizational capability at that level.

In general, the group of PAs at one maturity level is considered to be an essential foundation for the next increment of progress reflected in the maturity level that follows.

Maturity Levels 0 and 1

Maturity level 0 and maturity level 1 are not specifically defined, except to indicate that maturity level 2 has not yet been achieved.

Maturity Level 2

Maturity level 2 is called the Managed: Planned and Tracked level. The following nine process areas are staged at maturity level 2:

Lifecycle/Engineering Processes

- PA 02 Requirements
- PA 08 Evaluation
- PA 09 Deployment, Transition, and Disposal

Management/Project Processes

- PA 11 Project Management
- PA 12 Supplier Agreement Management

Supporting Processes

- PA 05 Outsourcing
- PA 15 Quality Assurance and Management
- PA 16 Configuration Management
- PA 18 Measurement and Analysis

To achieve maturity level 2, the nine process areas listed above must have satisfied capability levels 1 and 2 according to an iCMM appraisal.

Maturity Level 3

Maturity Level 3 is called the Defined level. The following eleven process areas are staged at maturity level 3:

Lifecycle/Engineering Processes

- PA 01 Needs
- PA 03 Design
- PA 06 Design Implementation
- PA 07 Integration

Management/Project Processes

- PA 00 Integrated Enterprise Management
- PA 13 Risk Management
- PA 14 Integrated Teaming

Supporting Processes

- PA 04 Alternatives Analysis
- PA 20 Process Definition
- PA 21 Process Improvement
- PA 22 Training

To achieve maturity level 3, all 20 process areas staged at maturity level 2 and maturity level 3 must have satisfied capability levels 1, 2, and 3 according to an iCMM appraisal.

Maturity Level 4

Maturity Level 4 is called the Quantitatively Managed level. There are no process areas staged at maturity level 4.

To achieve maturity level 4, all 20 process areas staged at maturity level 2 and maturity level 3 must have satisfied capability levels 1, 2, and 3 and selected process areas additionally must have satisfied capability level 4 (see Notes on Levels 4 and 5 on next page) according to iCMM appraisal.

Maturity Level 5

Maturity level 5 is called the Optimizing level. The following process area is staged at maturity level 5:

Supporting Processes

- PA 23 Innovation

To achieve maturity level 5, all 21 process areas staged at maturity levels 2, 3, 4, and 5 must have satisfied capability levels 1, 2, and 3 and selected process areas additionally satisfy capability levels 4 and 5 (see Notes on Levels 4 and 5 below) according to an iCMM appraisal.

Notes on Levels 4 and 5

To reach maturity levels 4 and 5, specific process areas are required to attain capability levels 4 and 5. These are selected based on the business objectives of the organization.

Users may wish to extend their capability level targets for individual process areas above capability level 3. This extension is appraisable if a valid mapping of processes to process areas has been constructed, so that it is possible to tell whether a process area has been placed under statistical process control.

Process Areas for Selective Use

The following two process areas are not staged for CMM benchmarking purposes since their content has not yet been included in any CMM benchmarks.

- PA 10 Operation and Support
- PA 17 Information Management

However, a reasonable staging consideration for these process areas might be to stage Information Management at maturity level 2, and Operation and Support at maturity level 3.

General Guidance

When selecting process areas and capability levels for improvement targets, it is important to pay attention to the dependencies between generic practices and process areas. When a generic practice is dependent upon a certain process area, either to perform the generic practice or to provide a prerequisite product, the generic practice will be ineffective if the process area is not implemented.

Alternative Stagings

Some alternative stagings are offered with the iCMM. These stagings offer possible ordering of process areas and capability levels for organizations with varying business objectives. For example, some organizations may focus mainly on engineering activities; some on operations and support; some are interested in ISO 9001 certification, or in pursuing compliance with other standards included in the iCMM; some organizations are mainly concerned with providing services.

Alternative stagings are described in iCMM companion documents (to be published separately).

2.8 Generic Attributes

Process Effectiveness

Although capability and maturity levels indicate the level of process discipline that organizational units may achieve in one or more process areas, the levels do not necessarily translate into work products or results that meet objectives. It is possible to have mature processes (e.g., capability level 3, 4, or 5) that produce unsatisfactory work products (e.g., of less than desirable quality, or that do not meet needs, for greater than expected expense). In such cases, process capability may not be aligned with performance.

ISO 9004 [ISO 9004] suggests consideration of self-assessment output together with the potential benefits to be gained for each process. ISO/IEC TR 15504-7:1998(E) [ISO/IEC TR 15504] describes effectiveness measures as: "the extent to which the software process achieves goals derived directly from an analysis of specific circumstances, needs and business goals of the organization." EIA/IS 731 [EIA/IS 731] describes similar measures as "Generic Attributes".

In general, organizations should establish specific objectives for work products and results of process execution that are tailored to organizational needs. The iCMM describes a refinement of EIA/IS 731 Generic Attributes that organizations may find useful, in lieu of establishing their own organization-unique process effectiveness measures.

Generic Attributes

Generic Attributes are a way of measuring two characteristics of process performance results, independently of capability and maturity level.: Usefulness and Cost Effectiveness. The Usefulness Generic Attribute indicates the traditional sense of value or usefulness of the products or results of performing processes relating to a process area. The Cost Effectiveness Generic Attribute indicates the extent to which the value received is worth the resources invested in producing the products or results. Generic Attributes are measured on a different scale from process capability and maturity and are not considered in the determination of process capability or maturity level. They are valuable as an independent check on the alignment of process capability and process performance.

Usefulness

Usefulness is defined as the extent to which work products or services provide the needed benefits in actual use.

Usefulness is determined for key work products or results of process areas as indicated in the following table.

Usefulness Value	The benefits of the work products or results of performing a process
U++	significantly exceed the need
U +	exceed the need to some degree
U	meet the need
U-	are somewhat lacking in meeting the need
U--	are substantially deficient in meeting the need

Table 2.1 Usefulness Generic Attribute

Projects should usually pursue Usefulness with caution, as exceeding expectations may result in unnecessary expense (lowered effectiveness).

The Usefulness Generic Attribute is closely related to validation of incremental work products described in the Evaluation Process Area (PA 08). PA 08 describes evaluation (validation) of the work products or services of a process to determine the extent to which they satisfy their intended use (need) in a representative operational environment. The Usefulness GA is the resulting value of the evaluation.

The method for appraising Usefulness will be described in the next version of the FAA-iCMM Appraisal Method [FAM]. Key aspects of appraising Usefulness involve identification of process area work products or results that will be the focus of the appraisal, and obtaining a Usefulness estimate from those using the identified work products or results (i.e., the “customer”).

Cost Effectiveness

Cost effectiveness is defined as the extent to which the benefits received are worth the resources invested.

The measure of cost effectiveness combines the concepts of usefulness (described above) and expected resource investment to obtain a qualitative measure of return on investment. The reference or target for resource investment for a given work product or result is the benchmarked standard. If actual benchmark values are not available, other credible reference values may be used – e.g., a value supported by a planning estimate. In order to determine cost effectiveness, intermediate data on resource efficiency is obtained as follows.

Resource Efficiency Value	Resources expended to produce the work product(s) or result(s)*
E++	were less than the expected (benchmarked) values by more than 50%
E+	were less than the expected (benchmarked) values by 5% to 50%
E	were within 5% of the expected (benchmarked) values
E-	were more than the expected (benchmarked) values by 5% to 50%
E--	exceeded the expected (benchmarked) values by more than 50%

* The exact percentages can be tailored by the organization.

Table 2.2 Resource Efficiency

The personnel assigning values in the above table are knowledgeable of the resource planning and expenditure relating to the identified work products or results, in contrast to the personnel making inputs on the Usefulness, who were the users of the products or services.

Cost Effectiveness (continued)

Cost effectiveness is determined according to the following graph.

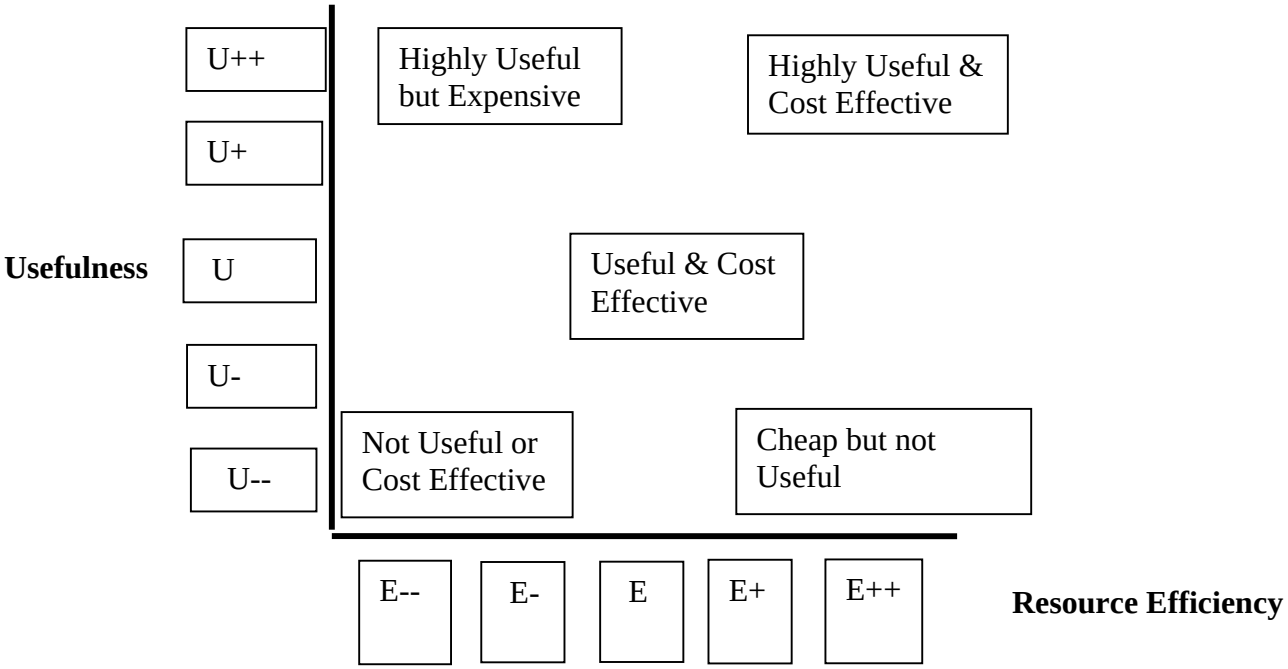

Figure 2.2 Cost Effectiveness

Usefulness and Cost Effectiveness can be used as an independent check on the value of an organization's processes and compared with the capability ratings of process areas to determine whether process capability is aligned with performance (Process Effectiveness).

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Chapter 3: Using the Model

Purpose of this chapter

This chapter provides information on using the iCMM for organizational process improvement and design.

In this chapter

The following table provides a guide to the information found in this chapter.

Topic	See Page
3.1 Usage Contexts	3-2
3.2 Using the iCMM to Support Process Improvement	3-5
3.3 Using the iCMM to Support Appraisal	3-11
3.4 Using the iCMM in Process Design	3-15

3.1 Usage Contexts

Introduction	The iCMM is useful in several contexts. These are discussed in this section.
General Applicability	The process improvement guidance in the model does not presume specific organizational structures, management philosophies, life cycle models, or methods. The concepts and principles are appropriate for a full range of different business needs, application domains, sizes and maturity of organizations; they may be used by all types of organizations to guide improvement activities.
Process and Life Cycle Scope	The scope of the process areas and practices makes the iCMM applicable to an enterprise or organization that engages in any or all of the following activities: acquisition, supply, engineering, research, development, operation, evolution, support, and management of products and services. Since the process areas cover the complete product or service life cycle, the model is pertinent to units engaged in any of the typical life cycle phases.
Products and Services	The iCMM is designed to be flexible with regard to the type of product or service being acquired, developed, operated, or provided. A service being provided may pertain to an area included in the model (e.g., testing or contracting services) or to any other service.
Level of Application	The model is intended for application in organizations that focus on high-level issues (e.g., public responsibility, strategic direction, or system architecture), on low-level issues (e.g., task management, mechanism selection, or design implementation), and for organizations that do both. A project can use the model to improve, as can a small organizational unit operating as a project, a large organizational unit comprising several units, or an overall enterprise.

Terminology	Every organization has its own particular culture, terminology, and communication style. Since it uses generic terminology, it is expected that iCMM concepts can be easily translated by all organizations into their own language and culture.
Role Independence	The process areas of the iCMM are groups of practices which, when taken together, achieve a common purpose. However, the groupings are not intended to imply that all base practices of a process are necessarily performed by a single individual or role. All base practices are written in verb-object format (i.e., without a specific subject) to minimize the perception that a particular base practice "belongs to" a particular role. This is one way in which the syntax of the model supports its use across a wide spectrum of organizational contexts.
Selective Use	Since all process areas may not be relevant in a particular organizational context, selected process areas of the model may be used, as applicable. In addition, the organization may need to look at relationships between different practices within the model to determine their applicability. When selecting process areas and capability levels for improvement targets, it is important to pay attention to the dependencies between generic practices and process areas. When a generic practice is dependent upon a certain process area, either to perform the generic practice or to provide a prerequisite product, the generic practice will be ineffective if the process area is not implemented.

Selective Use (continued)

Once the applicable process areas have been identified or selected, the generic practices provide guidance for improving the processes; generic attributes help evaluate the effectiveness of a process; and the appraisal method measures the capability, value, and effectiveness of a process in relation to the model.

A major advantage of the architecture of the iCMM is that it lays out a path to improve those processes that are most critical to the business needs of the organization.

Internal or External Use

There are two major ways that the iCMM can be used:

- Internal process improvement - performing internal appraisals to understand the organization's or project's process capability level for process improvement purposes.

- Independent capability evaluation - performing external evaluations to evaluate another organization's process capability.

The primary intended use for the model is for internal process improvement and that is the focus in this chapter. Information on performing external evaluations is provided in *The Federal Aviation Administration Integrated Capability Maturity Model*[sm] *(FAA-iCMM®) Appraisal Method (FAM)* [FAM] (available at www.faa.gov/aio).

3.2 Using the iCMM to Support Process Improvement

Introduction

Any process improvement effort, using any reference model, should be constructed to support the business goals of an organization. The needs and goals of the organization determine process improvement goals and identify improvement actions and priorities.

Process Improvement Basics

Successful changes typically start at the top of the organization. Senior management leadership is required to launch a change effort and to provide continuing resources and sponsorship. Ultimately, however, everyone in the organization is involved.

It is important to recognize that:

- Process improvement requires investment, planning, dedicated people, and time.
- Process improvement is a team effort; those not participating may miss the benefits and may even inhibit progress.
- Effective change requires an understanding of the current process and a goal.
- Change is continuous and involves continual learning and evolution.
- Changes will not be sustained without the conscious effort of everyone in the enterprise or organization, and the involvement and periodic reinforcement from every level of management.

When using a reference model like the iCMM to guide improvement, several tools are provided.

- The process areas provide best practice guidance for performing business processes.
- The capability levels provide a path for increasing the capability of those performed processes.
- The appraisal method measures process capability and effectiveness.
- Several process areas focus on process improvement itself.
- Establishing and achieving measurable objectives tied to business needs is emphasized throughout.

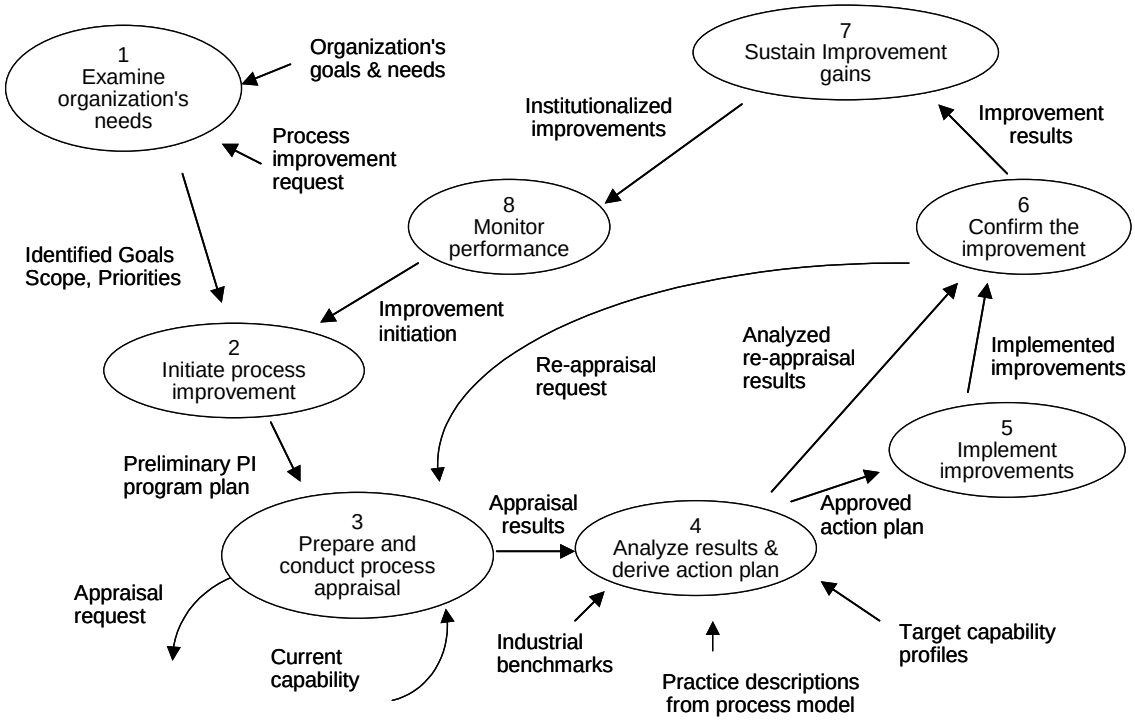

Figure 3-1. Process Improvement Cycle

Process Improvement Steps

Process improvement is accomplished in a series of steps or specific improvement actions. The figure above illustrates steps for continuous process improvement using tools provided in the iCMM. These steps are summarized below.

1. Examine organization's needs

- Purpose: Ensure process improvement is aligned with organization's needs
- Output: Quantitative process improvement goals tied to organization's business plan, scope, and priorities

2. Initiate process improvement

- Purpose: Ensure plan is laid out and infrastructure is in place
- Outputs: Preliminary program plan, charters, empowerment letters, resources, technical strategy (iCMM and FAM)

Process Improvement Steps (continued)

3. Prepare and conduct process appraisal

- Purpose: Determine current situation
- Output: Appraisal results

4. Analyze results and derive action plan

- Purpose: Decide on improvements and plan accordingly
- Outputs: Quantitative improvement targets; action plan, integrated with revised program plan; commitment to undertake planned improvements

5. Implement improvements

- Purpose: Carry out projects to improve processes
- Outputs: Project plans; improved processes; measures; process definitions, checklists, lessons learned, tailoring guidelines, training materials, sample documents

6. Confirm the improvement

- Purpose: Confirm improvement achieves goals and organization is ready for widespread use
- Output: Reappraisal results (on specific processes), measures, validated results

7. Sustain improvement gains

- Purpose: Institutionalize and monitor the improvement
- Output: Deployment plan, improved process assets entered into process asset library, widespread training on improved process, coaching and monitoring, measures

8. Monitor performance

- Purpose: Ensure program and projects remain appropriate, improve process improvement process
- Output: Further improvement initiatives, lessons learned

iCMM Guidance

The following process areas particularly help in carrying out the process improvement cycle:

- PA 00 Integrated Enterprise Management – for establishing high level goals and objectives and aligning them across the enterprise
- PA 11 Project Management – for managing the overall process improvement effort, and the efforts of improvement teams
- PA 15 Quality Assurance and Management – for assessing compliance and identifying improvement opportunities
- PA 18 Measurement and Analysis – for establishing, collecting, and analyzing measures relative to goals
- PA 20 Process Definition – for establishing and communicating process assets
- PA 21 Process Improvement – for more information on the steps outlined above

The FAM describes different appraisal approaches, including the use of generic attributes to evaluate process effectiveness. The FAM also includes a method variation to guide teams in improving processes.

Process Improvement Principles

As illustrated in the process improvement cycle, business goals are the primary driver in using a model such as the iCMM. An organization should prioritize the process areas relative to its business goals and strive for improvement in the highest priority process areas first. Within that context, however, there is a fundamental order of activities and basic principles that drive the sequence of typical improvement efforts. This sequence is shown in the generic practices of the capability level side of the iCMM architecture. The principles and order of activities are summarized in Table 3-1.

Principle	How Expressed in the iCMM
You have to do it before you can manage it.	The Performed level (capability level 1) focuses on whether an organization or project performs a process that incorporates the base practices.
Understand process performance on the project (where the products are!) before defining organization-wide processes.	The Managed: Planned and Tracked level (capability level 2) focuses on managing process performance at the project-level.
Use the best of what you've learned from your projects to create organization-wide processes.	The Defined level (capability level 3) focuses on establishing the organization's set of standard processes from experiences gained, and then using defined processes tailored from the standard processes. Both the defined and organizational processes are improved.
Managing with measurement is only meaningful when you're measuring the right things.	Measurement is required at capability levels 2 and 3. However, the Quantitatively Managed level (capability level 4) focuses on stabilizing process performance within statistically defined limits of key performance measures tied to the business goals of the organization.
A culture of continuous improvement pursues optimizing performance based on a foundation of sound management practice, defined and statistically controlled processes, and measurable goals.	The Optimizing level (capability level 5) gains leverage from all the improvements seen in the earlier levels, and emphasizes continual improvement of statistically controlled processes to meet current and projected business objectives.

Table 3-1. Process Improvement Principles in the iCMM

Some Expected Results	Based on analogies in the software community and elsewhere, some results of process and product improvement can be predicted. These are discussed below.
Improving Predictability	The first improvement expected as a project or an organization matures is *predictability*. As capability increases, the difference between targeted results and actual results decreases across projects. For instance, immature organizations often miss their originally scheduled delivery dates by a wide margin, whereas organizations at a higher capability level should be able to predict the outcome of cost and schedule aspects of a project with increased accuracy.
Improving Control	The second improvement expected as a project or an organization matures is *control.* As process capability increases, incremental results can be used to establish revised targets more accurately. Alternative corrective actions can be evaluated based on experience with the process and other projects' process results to select the best application of control measures. As a result, organizations with a higher capability level will be more effective in controlling performance within an acceptable range.
Improving Process Effectiveness	The third improvement expected as a project or organization matures is *process effectiveness*. Targeted results improve as the maturity of the organization increases. As an organization matures, costs decrease, development time decreases, and productivity and quality increase. In an immature organization, development time can be quite long because of the amount of rework that must be performed to correct mistakes. In contrast, organizations at higher maturity levels can shorten overall development times via increased process effectiveness and reduced rework.

3.3 Using the iCMM to Support Appraisal

Introduction

The iCMM is structured to support a wide variety of improvement activities, including self-administered appraisals or internal appraisals augmented by expert facilitators from inside or outside of the organization. Although it is primarily intended for internal process improvement, the model might also be used for external evaluation of another organization's process.

Appraisals are performed in the context of an organizational process improvement effort, and the type and tailoring are dependent on where in the organizational process improvement cycle the organization is.

The FAA-iCMM Appraisal Method

It is not required that any particular appraisal method be used with the iCMM. However, the FAA-iCMM Appraisal Method was designed and developed by the iCMM Project to maximize the utility of the model.

The FAA-iCMM Appraisal Method is fully described, along with support materials for conducting appraisals, in *The Federal Aviation Administration Integrated Capability Maturity Model*[sm] *(FAA-iCMM®) Appraisal Method (FAM)* [FAM]. The basic premises of the appraisal method, however, are summarized below to provide context for how the model might be used in an appraisal.

Features

The FAM is an organizational or project-level appraisal method that uses multiple data-gathering methods to obtain information on the processes being practiced within the organization or project selected for appraisal.

Appraisals are typically performed:

- to focus, motivate, direct, and/or launch improvement within the organization or project;
- as a diagnostic to determine status compared to a model or standard, or to track progress; and
- to form a baseline or benchmark of actual practice for self-improvement.

An appraisal will typically identify strengths and weaknesses in the appraised entity's process and produce a process capability profile that compares the appraised entity to a standard (the iCMM).

The method can be tailored to meet the organization's or project's need, and guidance on tailoring for a variety of appraisal scenarios is provided in the FAM document.

In general, data gathering consists of:

- questionnaires that directly reflect the contents of the model,
- a series of structured and unstructured interviews with key personnel involved in the performance of the processes, and
- review of evidence generated.

Multiple feedback sessions are conducted with the appraisal participants. This culminates in a briefing to all participants and to the sponsor of the appraisal. The briefing may include capability levels determined for each of the process areas appraised. It also includes a set of strengths and weaknesses that support process improvement based on the stated appraisal goals and may include a rating of maturity.

Variations

The FAM includes a full internal method, plus five method variations that can be used for a variety of appraisal situations and needs, as follows:

- *Full internal*: to establish or reestablish a formal baseline of actual practice in the organization
- *Facilitated discussion*: to formulate process descriptions and implementation plans
- *Document-intensive:* to check the completeness and quality of supporting documentation and artifacts
- *Questionnaire-based:* to provide a quick check on process improvement progress based on whether improvements are perceived to have been implemented by personnel
- *Interview-based:* to uncover major process improvement issues or barriers to change
- *Full external:* to perform a formal external appraisal of an organization

Additionally, process effectiveness can be explored during an appraisal through the use of generic attributes (described in Chapter 2).

Defining the Context for Appraisal

When planning for an appraisal, it is essential to understand the context for process improvement in the organization or project. The iCMM is intended to be applicable in all contexts. Determination of the context must be made to decide:

- What is the organizational appraisal scope (which organization or part of an organization will be appraised)
- What are the organizational business, performance, and appraisal goals
- Which process areas are applicable to the organization
- How should the process areas be interpreted (for example, in a development vs. operational vs. service environment)
- Which personnel within the appraisal scope need to be involved in the appraisal

Using Both Sides of the Architecture in Appraisal

The first step in developing a profile of an organization's capability to perform its business processes is to determine whether the basic processes (all the base practices) are performed within the organization. The second step is to appraise how well the processes that have been implemented are managed and institutionalized by looking at the processes in the context of the generic practices. Consideration of both the base practices and generic practices in this way results in a process capability profile that can help the organization to determine the improvement activities that will be of most benefit in the context of its business goals.

In general, the appraisal evaluates each process area against the generic practices. The base practices should be viewed as guidance on the basic performance of the topics that need to be addressed. The generic practices deal with improvement in the way the base practices are performed. In many cases, the generic practices are supported by process areas that provide more detail about them. Thus by looking at the generic practices, an appraisal evaluates how those supportive process areas have been deployed.

Process area goals and capability level goals summarize practices and are used during an appraisal. Strengths and weaknesses found in particular practices are considered in relation to the goals to which they are mapped, and a determination is made as to whether the goals have been achieved.

3.4 Using the iCMM in Process Design

Introduction	This section provides brief guidance related to using the iCMM to support process design. Some basic ground rules and approaches are presented.
The iCMM doesn't define the process	A common misconception is that the iCMM defines a specific process. The iCMM provides guidance for organizations to define their own processes and then improve them over time. The guidance applies regardless of the particular processes that are performed. The generic practices describe what activities must be performed to help define, manage, monitor, and improve the organization's process rather than exactly how those activities must be performed. The base practices describe fundamental activities that should be performed as part of a process, but they do not specify exactly how these activities must be performed. The basic philosophy is to empower organizations to develop and improve a process that is most effective for them. This is based on the ability to define, document, manage, and standardize the process throughout the entire organization. The philosophy is not focused on any specific lifecycle, organizational structure, or techniques.
How much documentation is required?	When reading the iCMM, it is easy to get overwhelmed by the number of implied processes and plans. The iCMM includes requirements to document processes and procedures and then make sure they are performed as documented. However, the iCMM does not intend to dictate the number or type of documents to be developed but rather to indicate the type of information that is to be documented.
The iCMM is not a training guide	While the iCMM is intended to guide organizations in improving their capability to perform a particular process, it is not intended to be a handbook or training guide for helping individuals improve particular skills. The goal is for an organization to adopt the philosophy and use the techniques as a guide for defining and improving its process.

But, we're different

The iCMM contains sound practical guidance that can be used in most business situations. By analyzing the organization and its activities, and interpreting iCMM practices and terminology in that context, any organization can benefit from the improvement guidance in the iCMM.

Analyzing your Organizational Context

The first step in designing processes that will meet the business needs of an enterprise is to understand the business, product, and organizational context that already exists or that will be present when the process is implemented. Some questions that need to be answered before the iCMM can be used for process design include:

- What is the main business function of the organization?
- Who are the customers and what are their expectations?
- What products and services are being provided?
- What major processes are being practiced to provide these products and services?
- How are they being practiced within the organization?
- What lifecycle will be used as a framework for this process?
- How is the organization structured to support projects?
- How are support functions handled (e.g., by the project or the organization)?
- What are the management and practitioner roles used in this organization?
- How critical are these processes to organizational success?

Understanding the cultural and business contexts in which the iCMM will be used is a key to its successful application in process design.

The Current Process

An organization should first describe with reasonable accuracy its current process as a baseline. It is best to focus on capturing a reasonable baseline process that can be improved over time.

Organizations must have a stable baseline to determine whether future changes constitute improvements. There is no value in looking for improvements in a process that the organization does not perform. An organization may find it useful to include current delays and queues in the baseline process. During subsequent process improvement efforts, these allow a good starting point for cycle-time reduction.

An organization may define its process by analyzing the responsibilities of its practitioners. This would identify activities currently being performed and help establish interfaces among the various management, engineering, and support processes.

Mapping

The actual processes used in an organization depend on many factors including its size and structure, application domain, and whether it is product- or service-oriented. The process areas of the iCMM may not map one-to-one with the processes used in the organization. Nor is it required or expected that this be the case. A process description may span more than one process area, and a process may be described in more than one way (e.g., policies, standards, procedures) to cover a process area.

However, locating the parts of the organization process that map to process areas enables use of the model to guide improvement. If gaps are identified between the current process and the practices in the model, then this indicates an area for potential improvement.

The practices of many of the process areas would be expected to be seen a number of times in the execution of processes through the life cycle. Thus, the process areas should be considered a source for practices whenever there is a need to incorporate the purpose of a process area in a project's or organization's process.

Adding Role and Structure Information	Role assignment, organizational structure, and work products need to be added to the content of the iCMM process areas and generic practices to come up with a performable and sustainable process design. It is an organization's context regarding these factors, combined with guidance from iCMM generic practices and base practices, that produce sound organizational processes with the potential for deliberate improvement.
Additional Guidance	For additional information about using the iCMM in process design, see the Facilitated Discussion appraisal method variation in the FAM. That method variation is designed to help a team understand and describe a current process, analyze it for improvement opportunities, describe an improved process, and develop a plan to implement improvements.

Part 2: Model Description

Chapter 4: Generic Practices

Chapter 5: Process Areas and Base Practices

Chapter 4: Generic Practices

Purpose of this chapter

This chapter contains the generic practices, that is, the practices that apply to all processes. Generic practices provide a guide to institutionalization of a process and they are also used in a process appraisal to determine the capability of any process. The generic practices are grouped according to capability level.

In this chapter

The following table provides a guide to the information found in the chapter.

Topic	See Page
Capability Levels - Overview, Sources, and Format	4-2
Capability Level 0 - Incomplete	4-5
Capability Level 1 - Performed	4-6
Capability Level 2 - Managed: Planned and Tracked	4-8
Capability Level 3 - Defined	4-22
Capability Level 4 - Quantitatively Managed	4-28
Capability Level 5 - Optimizing	4-31

Capability Levels - Overview, Sources, and Format

Introduction

Capability levels provide guidance for the improvement of any process. There are six levels of capability. The lowest is Level 0 and the highest is Level 5. Capability levels can be used as goals, guidance, benchmarks, or other means to assist an organization in structuring its improvement efforts.

The capability levels group together generic practices (GPs) that are used to institutionalize process capability at that level. These generic practices build upon each other as process capability increases.

Getting Started

Initially, a process may not be performed or may be only partially performed. This is called an incomplete process or a process of capability level 0. The first improvement step is to perform a process that achieves the goals of a process area. This is called a performed process of capability level 1. At this point the base practices are generally being carried out, and products and services are being provided to a customer. From here on, all improvements are made to a process that continues to meet the goals of the process area. However, the capability of that process is improved.

Managing the Process

Once the process is performed, it can be planned and tracked and managed. A performed process that is also managed is called a managed (planned and tracked) process of capability level 2. The capability level 2 process is carried out according to a documented plan and process description. The plan contains the business objectives for performing the process. There are adequate resources for performing the process; people have the needed skill; roles and responsibilities are clear; work products are verified and controlled; performance is measured against the plan; and corrective actions are taken to address problems. Corrective actions at capability level 2 include improving the process. Improvements are generally local however, and may not be transferred beyond the performing unit.

Organizational Learning and Improvement	Based on organizational business objectives and practitioner knowledge and experience in carrying out managed (planned and tracked) processes, an organization establishes a standard set of organizational processes at capability level 3. Projects or organizations tailor this standard process into what is called a defined process. The defined process is used, measured, and improved, and process information is stored in an organizational repository. Process knowledge is shared across the organization. Improvements are made to the organizational standard processes and to the defined processes. Improvement is deployed across the organization.
Stabilizing Performance	At capability level 4, the emphasis is on understanding the capability of a process statistically. Very specific business objectives, measures, and processes are selected for quantitative management and the performance of those processes is stabilized by discovering, analyzing, and removing special causes of process variation. Process performance is now within statistically determined control limits and there is an understanding of what levels of business performance are actually statistically achievable.
Optimizing Performance	Finally, at capability level 5, improvements focus on introducing changes to those processes that are now under statistical control. These changes try to shift the expected (mean) performance value by removing common causes of process variation or by introducing new technology. This level seeks to optimize performance to meet ever-stretching target levels set by the organization for performance excellence.
Institutionalization	"Institutionalization" is an important dimension to the capability levels. It 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. Institutionalization implies that the breadth and depth of the implementation of the process and the length of time the process has been in place are appropriate to ensure that the process is an ingrained part of the way the work is performed. Implementation of the generic practices is a mechanism used to institutionalize enhanced process capability at the different levels.

Sources

Capability levels are defined based on widely observed plateaus of performance that organizations typically achieve as they strive to improve their business processes. These levels have been described in the various models and standards noted below.

For version 1.0: The FAA-iCMM v1.0 [FAA-iCMM 97] generic practices were derived and adapted from the Common CMM Framework (CCF) [CCF] and the SE-CMM [SE-CMM], with two additional generic practices developed by the FAA-iCMM team.

For version 2.0: The FAA-iCMM v2.0 generic practices have been derived and adapted from the following sources:

- [FAA-iCMM 97]
- [EIA/IS 731]
- [CMMI SE/SW/IPPD]
- [ISO/IEC TR 15504].

A mapping of capability level goals and generic practices to their sources is included in Appendix D Supplement.

Format

Capability levels are described in the following general format:

- Capability level number and title
- Capability level summary description
- Capability level goal
- Generic practices at that level
  - Generic practice number
  - Generic practice title
  - Generic practice statement
  - Notes (optional)
  - Relationship to other generic practices (optional)
  - Relationship to process areas (optional)

Notes on Relationships

A generic practice may depend on a process area to perform that practice. When a process area is identified as being related to a generic practice, the process area supports that practice and provides more detailed guidance for performing the generic practice. The related generic practice focuses on deploying these practices in relation to individual process areas.

Capability Level 0 – Incomplete

Level 0 Description	An incomplete process is either not performed or partially performed. One or more of the goals of the process area are not achieved. The process is not implemented.
Level 0 Goal	There is no goal at this level.
Level 0 Generic Practices	There are no generic practices at this level.

Capability Level 1 – Performed

Level 1 Description	A performed process is a process that achieves the goals of the process area. Base practices of the process area are generally performed. At this level, all base practices are generally performed somewhere in the project's or organization's implemented process, but processes are characterized as ad hoc and even occasionally chaotic. Consistent planning and tracking of performance are missing. Good performance, therefore, depends on individual knowledge and effort. Work products are generally adequate, but quality and efficiency of production depend on how well individuals within the organization perceive that tasks should be performed. Based on experience, there is general assurance that an action will be performed adequately when required. However, the capability to perform an activity is not generally repeatable or transferable. The main distinction between an incomplete process and a performed process is that a performed process achieves all of the goals of the process area.
Level 1 Goal	The process achieves the goals of the process area.

Level 1 Generic Practices

1.1 Identify Work Scope	Identify the scope of the work to be performed and work products or services to be produced, and communicate this information to those performing the work. *Notes:* The purpose of this practice is to ensure that the people doing the work have a common understanding of the work to be performed and work products to be produced. *Relationship to other generic practices:* This practice evolves from informal communication at level 1 to more formal communication at level 2 by means of documented process descriptions (GP 2.2) and plans (GP 2.3).

1.2 Perform the Process

Perform a process that implements the base practices of the process area to provide work products and/or services to a customer.

Notes: The purpose of this practice is to produce the work products and/or deliver the services that are expected by performing the process. This process may be performed informally, not following a documented process description or plan. The rigor with which these practices are performed may vary considerably. The customer of the process area may be internal or external to the project or organization.

Alternative practices to the base practices may be performed as long as the process area goals are achieved.

Relationship to other generic practices: This generic practice evolves to GP 2.8 at level 2, and to GP 3.2 at level 3.

Relationship to process areas: The process area goals and base practices are presented in the process area descriptions.

Capability Level 2 - Managed: Planned and Tracked

Level 2 Description

A managed process is a performed (capability level 1) process that is also planned and tracked. The process is managed to ensure its institutionalization, and to ensure the achievement of specific objectives for the process, such as customer satisfaction, cost, schedule, and quality objectives.

Those responsible for performing the process establish objectives considering their business context. Objectives are determined based on an understanding of what will satisfy the relevant stakeholders. Objectives may be quantitative or qualitative. They may be specific to the individual process or they may be defined at a higher level or for a group of processes, with the individual processes contributing to achieving these objectives. Objectives may be revised as part of corrective actions taken for the process.

At capability level 2, management is assured that: the process is being performed; process performance is planned, tracked, measured, reviewed, verified, and predictable; policy is followed; corrective action is taken. Practitioners are assured that: they have adequate skills; responsibilities are clear; resources are adequate; work products are managed; the process is understood. Customers are assured that requirements and standards for work products and services are defined and documented, and that work products and services satisfy their specified requirements and standards. For all involved in the process, commitments are established, understood, honored and revised as necessary.

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

The primary distinction between a performed process and a managed (planned and tracked) process is the extent to which a process is managed. A managed process is planned and the performance of the process is tracked against the plan. Corrective actions are taken when the actual results and performance deviate from the plan. A managed (planned and tracked) process achieves the objectives of the plan and is institutionalized for consistent performance. Institutionalization is accomplished by performing the generic practices.

Level 2 Goal

The process is institutionalized as a managed (planned and tracked) process.

Level 2 Generic Practices

2.1 Establish Organizational Policy

Establish and maintain an organizational policy for performing the process.

Notes: 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. Policy is a visible way for organizations and their leaders to set expectations. It is a way of demonstrating management commitment and attention to process improvement. The form policy takes, or the name given to senior management direction, may vary depending on the local culture. The existence of appropriate organizational direction is the expectation of this practice, regardless of what it is called.

Policy typically specifies expectations for planning, tracking, and performing the process.

Relationship to process areas: Integrated Enterprise Management (PA 00) provides guidance regarding establishing and communicating senior management direction and expectations.

2.2 Document the Process

Document the process for performing the practices of the process area.

Notes: The purpose of this practice is to establish a written description of the activities that will be performed so that people know what to do, and so that the process can be reviewed and improved. When documenting the process, participation of the people who perform a process is essential to creating a usable process description. The process should be documented only to the extent of detail needed and it should be in a form that is usable by those who will perform the process. Processes need not correspond one to one with the process areas in the FAA-iCMM. Therefore, a process description may span more than one process area, and a process may be described in more than one way (e.g., policies, standards, plans and/or procedures) to cover a process area. The process description, including relevant standards and procedures, may be included as part of the plan for the process, or may be included in the plan by reference.

Relationship to other generic practices: This is the level 2 process description that focuses on the information needed for those performing the process, not on the organization-wide formal defined process. The process descriptions evolve to a more formal defined process at capability level 3 (see GP 3.2).

Standards and procedures that describe the process at this level are likely to include measurements, so that the performance can be tracked with measurement (see GP 2.12).

Relationship to process areas: Process Definition (PA 20) provides guidance for documenting the process. Guidance for identifying activities to be performed is provided in Project Management (PA 11).

2.3 Plan the Process Establish and maintain a plan to accomplish the objectives of the process.

Notes: The purpose of this practice is to determine what is needed to perform the process and achieve the established objectives, and prepare a plan accordingly. Establishing a plan includes documenting it. Maintaining the plan includes changing it as a result of corrective actions, changes to the process, and changes to the objectives for the process, as necessary.

Those responsible for performing the process establish objectives considering their business context. Objectives are determined based on an understanding of what will satisfy the relevant stakeholders. Objectives may be quantitative or qualitative. They may be specific to the individual process or they may be defined at a higher level or for a group of processes, with the individual processes contributing to achieving these objectives. Objectives may be revised as part of corrective actions taken for the process.

The plan may be a standalone document, embedded in a more comprehensive document (for example in a project or organizational plan), or distributed across multiple documents.

A plan for a process typically includes:

- Objectives for the performance of the process (e.g. cost, schedule, quality, customer satisfaction, delivery, time-scale, cycle time, productivity, resource usage, predictability, or profit objectives)
- Activities of the process and activity dependencies
- The process infrastructure required for performing the process
- Resources needed to perform the process, including funding, people, tools, and any products used in performing the process
- Standards/requirements for the work products and services of the process
- Schedule (events and activity dependencies) for performing 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

Capability Level 2 - Managed: Planned and Tracked, continued

2.3 Plan the Process (continued)

- Measurement requirements to provide insight into the performance of the process, its work products, and its services
- Activities for monitoring and controlling the process
- Communication mechanisms and activities
- Objective verification activities for the work products and services
- Objective assessment activities for the process
- Management review activities for the process and the work products

Relationship to other generic practices: The documentation of the process (in GP 2.2) identifies activities to be planned. Adequate resources (in GP2.4) are defined by the plan. Commitment to the plan is confirmed through GP2.15.

Relationship to process areas: In some process areas there are base practices that also talk about developing strategies or plans. This generic practice addresses overall planning for the entire process area, whereas base practices address a topic for more detailed or focused planning. Planning is described in Project Management (PA 11). Measurement practices are described in Measurement and Analysis (PA 18).

2.4 Provide Adequate Resources

Provide resources that are adequate for performing the process as planned.

Notes: 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 and work environment, skilled people, adequate time, products used in performing the process, and appropriate tools. This practice ensures that level of effort, appropriate skill mix, tools, workspace, and other direct resources are available to perform the process. Inadequate resources may be addressed by increasing resources or by removing requirements, constraints, and commitments.

Relationship to other generic practices: Resource requirements are identified in the plan (GP2.3).

Relationship to process areas: Practices regarding identification of critical resources and assuring resource commitment are described in Project Management (PA 11).

Capability Level 2 - Managed: Planned and Tracked, continued

2.5 Assign Responsibility

Establish responsibility, authority, and commitment for performing the process.

Notes: The purpose of this practice is to ensure that there is accountability for performing the process and achieving the specified results. This practice entails obtaining commitment for performing the process, and assuring not only that people are assigned, but confirming their understanding and acceptance of responsibility for outcomes. Responsibility includes both duty to perform and accountability for successful performance. This practice includes overall responsibility and authority for performing the process as well as assignment for performing specific tasks of the process.

Responsibility can be assigned using detailed job descriptions or through living documents, such as a plan for the process. Dynamic assignment of responsibility is another possible implementation of this practice, as long as there are mechanisms in place to assure that the responsibility is assumed.

Relationship to other generic practices: Responsibility and authority may be assigned in the plan for the process as described in GP2.3, and commitment demonstrated by concurrence on that plan and as described in GP 2.15.

Relationship to process areas: Project Management (PA 11) practices provide guidance regarding establishing responsibility and commitment.

2.6 Ensure Skill and Knowledge

Ensure that the people performing the process have the needed skill and knowledge.

Notes: The purpose of this practice is to ensure that the people have the necessary skills, knowledge, and expertise to perform or support the process. Included are technical skill and knowledge as well as an understanding of how the process is expected to be performed. A variety of approaches can be used including training, mentoring, coaching, and hiring people with the required talent. Overview training is provided to orient people who interact with those performing the work.

Training in how the project expects the process to be performed provides a common understanding of the process. Ensuring that people can perform the process adequately provides the confidence basis for schedule and cost estimation. Even if apparently satisfactory technical skills and knowledge are available via staffing or partnering, there is almost always a need to establish a common understanding of the process activities and how skills are applied in them.

Relationship to other generic practices: Required skills can be identified in the process plan (GP 2.3) which may include training in the schedule of activities.

Relationship to process areas: Training and training management are described in Training (PA 22). Planning for appropriate skill and knowledge is described in Project Management (PA 11). Outsourcing to acquire needed skill is described in Outsourcing (PA 05).

2.7 Establish Work Product Requirements	Establish and maintain requirements on work products and services that result from the process. *Notes:* The purpose of this practice is to ensure clarity regarding the requirements associated with work products and services that result from the process. These requirements are used in developing products and services, and in verifying that products and services meet requirements. These requirements may come from the customer, policies, standards, laws, regulations, etc. *Relationship to other generic practices:* Requirements are used in objectively verifying work products (GP2.11). Requirements can be documented in the process plan (GP 2.3). *Relationship to process areas:* Understanding stakeholder needs is described in Needs (PA 01). Requirements development is described in Requirements (PA 02).
2.8 Consistently Use and Manage the Process	Consistently use the documented plans, standards, processes, or procedures in implementing and managing (planning and tracking) the process. *Notes:* The purpose of this practice is to use the documented process and plan while performing the base practices of the process area. Consistent use over time leads to institutionalization of the process as an ingrained way of performing the work. Consistent management assures planning, execution, and tracking of the process in order to achieve process objectives. *Relationship to other generic practices:* The process, standards and procedures to use were documented in GP 2.2. The plans to use were documented in GP 2.3. This practice is an evolution of GP 1.2 and evolves to GP 3.2. *Relationship to process areas:* Project Management (PA 11) provides guidance regarding process management.

2.9 Manage Work Products

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

Notes: The purpose of this practice is to establish and maintain the integrity of the designated work products of the process. Placing identified work products of the process under appropriate levels of configuration management provides a means of controlling work products. This practice is focused on controlling interim or final work products, parts, components, etc. resulting from an individual process. These work products may also include process descriptions, plans, action item lists, etc.

Relationship to other generic practices: The work products to be placed under configuration management and the level of configuration management for each item may be documented in the plan for the process (GP2.3).

Relationship to process areas: The typical practices needed to perform configuration management are described in Configuration Management (PA 16).

2.10 Objectively Assess Process Compliance

Objectively assess adherence of the performed process to the documented process.

Notes: The purpose of this practice is to provide credible assurance that the process is performed as documented and planned. People not directly responsible for managing or performing the process typically are positioned to assess process compliance objectively. As a result of objective assessment, credible assurance of compliance can be provided even during times when the process is under stress (e.g., when the effort is behind schedule or over budget). This practice includes identifying and reporting noncompliance issues and performing causal analysis.

Relationship to other generic practices: The applicable processes, standards and procedures are documented in GP 2.2, planned in GP 2.3, and used in GP 2.8. If corrective action is required, this is performed using GP 2.14.

Relationship to process areas: Process compliance and causal analysis practices are described in Quality Assurance and Management (PA 15).

2.11 Objectively Verify Work Products

Objectively verify adherence of work products and services to established requirements.

Notes: The purpose of this practice is to assure that work products and services of the process meet established requirements. Work products include documents or interim work products as well as delivered products and services. Performing defect reviews of work products with peers is a potential means for performing this practice. This generic practice includes identifying and reporting noncompliance issues and performing causal analysis.

Relationship to other generic practices: The requirements on work products and services are established using GP 2.7. If corrective action is required, this is performed using GP 2.14.

Relationship to process areas: Verification and validation are addressed in Evaluation (PA 08). Product/service quality assurance and causal analysis practices are described in Quality Assurance and Management (PA 15).

2.12 Measure Process Performance

Measure performance against the plan.

Notes: The purpose of this practice is to monitor, track, and measure process performance against the plan to ensure visibility into the process and to identify problems that may need corrective action. The plan identifies objectives, such as cost, schedule, quality, or customer satisfaction objectives, and measures associated with these objectives. Actual vs. planned values of these measures are recorded and used in this practice. Building a history of measures, such as cost and schedule variances or quality levels, is a foundation for managing by data, and is begun here.

This practice includes review of accomplishments and results of the process against the plan, and identification and evaluation of the effects of significant deviations from the plan. Such reviews, performed with those immediately responsible for the process, ensure visibility into the process.

Relationship to other generic practices: The use of measurement implies that the measures have been defined and selected in the process description (GP 2.2) or in the plan (GP 2.3) and that measurement data are collected as the process is used and managed (in GP 2.8). Reviews with senior management are described in GP 2.13.

Relationship to process areas: Project tracking is described in Project Management (PA 11). Performance evaluation based on measurement is described in Integrated Enterprise Management (PA 00). Measurement practices are described in Measurement and Analysis (PA 18).

2.13 Review Performance with Higher-level Management

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

Notes: The purpose of this practice is to provide higher-level management with the appropriate level of visibility into the process.

Higher-level management includes those levels of management 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.

Different managers will have different oversight needs. The project manager will need to remain informed of status and take corrective action when issues that cannot be handled at a lower level are escalated for their intervention. Senior management will typically keep strategic oversight of the process and take corrective action on issues that span multiple projects. Customer management may choose to oversee specific processes and/or products. These reviews help ensure that informed decisions on planning and performing of the process can be made. Therefore, these reviews are expected to be both periodic and event-driven.

Relationship to other generic practices: Several generic practices provide input for review including GP 2.10, GP 2.11, and GP 2.12. Reviews conducted here may result in the need for corrective action in GP 2.14.

Relationship to process areas: Review practices are addressed in Project Management (PA 11).

2.14 Take Corrective Action

Take corrective actions to address problems.

Notes: The purpose of this practice is to take corrective action when requirements and objectives are not being satisfied, when noncompliance or other issues are identified, or when progress differs significantly from the plan.

Progress may vary because estimates were inaccurate, performance was affected by external factors, or the objectives and requirements, on which the plan was based, have changed. Corrective action may involve:

- taking remedial action to repair defective work products or services
- improving the process
- changing the plan
- changing the technology
- changing the skill and knowledge base
- adjusting resources, including people, tools, and other resources
- negotiating changes to the established commitments
- negotiating change to process objectives
- securing change to the requirements and standards that have to be satisfied
- terminating the effort
- an explicit decision not to act at this time

Corrective action may be taken at the level of the individual worker, by the immediate manager of the process, by the project manager, or by senior management depending on the extent and scope of the problem.

Relationship to other generic practices: Results of performing generic practices GP 2.10, GP 2.11, GP 2.12, and GP 2.13 may lead to the need for corrective action.

Relationship to process areas: Taking corrective action is described in Project Management (PA 11) and Integrated Enterprise Management (PA 00). Process improvement is described in Process Improvement (PA 21).

2.15 Coordinate With Participants and Stakeholders

Coordinate and communicate among those performing the process and with appropriate stakeholders.

Notes: The purpose of this practice is to ensure common or mutual understanding of expected participant and stakeholder involvement, and that participants and stakeholders are involved as planned. This practice includes identifying relevant participants and stakeholders and their expected involvement in the process. They may be from groups either inside or outside the organization.

Items requiring coordination include changes to plans, products, processes, activities, requirements, and responsibilities. Commitments, expectations, and responsibilities are documented and agreed upon. Commitment may be obtained by negotiation, by using inputs and feedback on input, or through joint development of solutions to issues. Issues are tracked and resolved within the group.

Communication occurs periodically and whenever status changes. The participants and stakeholders have access to data, status information, and recommended actions.

Participants and stakeholders may change as the project progresses.

Relationship to other generic practices: The plan used for coordination is developed in GP2.3.

Relationship to process areas: Commitment, coordination, and communication are addressed in Project Management (PA 11) and Integrated Teaming (PA 14). Participants and stakeholder identification is addressed in Needs (PA 01) and Integrated Teaming (PA 14). Supplier coordination is addressed in Outsourcing (PA 05) and Supplier Agreement Management (PA 12).

Capability Level 3 - Defined

Level 3 Description

A defined process is a managed, planned and tracked (capability level 2) 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.

The organization's set of standard processes, which forms the basis of the defined process, is established to meet specific business objectives for the organization. The standard processes implement the base practices and support the performance of a managed (planned and tracked) process. These processes are established based on experience captured using previous and current processes.

Data and experiences from using the defined process are gathered and used to determine if change is needed. Accordingly, both the set of standard processes and the defined processes are improved.

A critical distinction between a managed process and a defined process is the scope of application of the standards, process descriptions, and procedures. For a managed process, the standards, process descriptions, and procedures may be in use in only a specific instance of the process (e.g., on a particular project). Because the standards, process descriptions, and procedures are tailored from the organization's set of standard processes and related organizational process assets, the defined processes that are performed across the organization are appropriately consistent. The capability to perform a defined process is directly transferable to new projects within the organization.

Another critical distinction is that a defined process is described in more detail and performed more rigorously than a managed process. Management of the defined process is based on the additional insight provided by an understanding of the interrelationships of the process activities and detailed measures of the process, its work products, and its services.

Description (continued)	A defined process is tailored from an organizational standard process and clearly states the following: • Purpose • Inputs • Entry criteria • Activities • Roles • Measures • Verification steps • Outputs • Exit criteria
Level 3 Goal	The process is institutionalized as a defined process.

Level 3 Generic Practices

3.1 Standardize the Process

Establish and maintain a set of standard processes for the organization, including tailoring guidelines.

Notes: The purpose of this practice is to establish and maintain a set of processes designed to meet specific business goals for the organization. The set of standard processes is based on experience captured from using previous and current processes and provides a mechanism for organizational learning. The set of standard processes supports the execution of the managed, planned and tracked process and thus includes the level 2 generic practices. It is established to provide a common basis for developing the defined processes that are used across the organization.

The critical distinction between the capability level 2 generic practice "Document the process " and this practice is the scope of application of the policies, standards, and procedures. In the planned and tracked practice (GP2.2), the standards and procedures may be in use in only a specific instance of the process, e.g. on a particular project. In this practice, however, policies, standards, and procedures are being established at an organizational level for common use throughout the organization. In addition, whereas the documented process at level 2 is the process that is directly used, the standard set of processes established in this practice need to be tailored and instantiated into a defined process for direct use (see GP 3.2).

The processes in an organization need not correspond one-to-one with the process areas in the FAA-iCMM. An organization's process is likely to span multiple process areas. Also, the organization may define more than one standard process for a process area to address differences among application domains, customer constraints, etc.

Relationship to other generic practices: The level 2 process description was documented in GP 2.2. The level 3 process description is established in GP 3.2.

Relationship to process areas: The process for developing a process description is described in Process Definition (PA 20).

3.2 Establish and Use a Defined Process

Establish and use a defined process, designed to meet specific business objectives, that is tailored from the organization's set of standard processes.

Notes: The purpose of this practice is to establish and use a process that is tailored from the set of standard processes to address the needs of a specific situation. That tailored process is called the defined process. The defined process has clearly stated purpose, inputs, entry criteria, activities, roles, measures, verification steps, outputs, and exit criteria and is tailored from an organization's set of standard processes. With the use of a defined process, there is less variability in how processes are performed across the organization and process assets, data, and learning can be effectively shared.

This practice includes selecting the standard process that best fits the situation, establishing the defined process by tailoring according to tailoring guidelines, ensuring the organization's process objectives are appropriately addressed in the defined process, documenting the defined process, and revising that description as necessary.

Exceptions may be driven by customer requirements or by the need to pilot new processes. Exceptions should not omit lower level practices without explicit review and risk assessment.

Relationship to other generic practices: The set of organization's standard processes, along with tailoring guidelines, are documented in GP 3.1. The tailored process definition is established and used in GP 3.2. This generic practice is similar to GP 2.8 except that it includes establishing the defined process as well as using it.

Relationship to process areas: Tailoring guidelines are described in Process Definition (PA 20).

3.3 Improve Processes

Collect and use work products, measures, measurement results, and improvement information to improve the standard and defined processes.

Notes: The purpose of this practice is improve the standard and defined processes based on experience gained in their use.

This practice includes collecting measures, measurement results, lessons learned, information and artifacts and storing them in an organizational repository or library of process-related assets. This information is made available to those who are planning and performing processes, and to those who use this information to improve the standard and defined processes. The information is used to improve the process and it is made available to those who need it in a timely manner.

The organization's standard process assets are artifacts that relate to describing, implementing, and improving processes. These artifacts are assets because they 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. The use of standard process assets results in organizational learning that is sponsored, supported, and addresses strategic business needs

The improvements to the standard and defined processes may be driven by incremental internal improvements, or by innovations introduced here or at capability level 5. In other words, this practice is the focal point for all changes to standard or defined processes. Proposed changes are evaluated in relation to defined business goals for the process.

This practice includes deploying the improved set of standard processes across the organization. Deployment is managed to ensure that any disruption to process performance is understood and minimized.

Relationship to other generic practices: At level 2, improvements to the managed process are made as a result of taking corrective action (GP 2.14), whereas this practice focuses directly on improving the standard and defined processes.

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Capability Level 3 - Defined, continued

3.3 Improve Processes (continued)	*Relationship to process areas:* Process improvement activities are described in Process Improvement (PA 21). Process assets are described in Process Definition (PA 20). Information Management (PA 17) provides guidance for storing, protecting, and sharing information. Measurement and Analysis (PA 18) includes practices for establishing, collecting, storing and analyzing measurement data.

Capability Level 4 - Quantitatively Managed

Level 4 Description

A quantitatively managed process is a defined (capability level 3) process that is controlled using statistical and other quantitative techniques. Quantitative objectives for process performance are used in managing process performance. The capability of the process, in terms of the range of expected performance results for selected attributes, is understood statistically. The defined process has been stabilized by eliminating special causes of process variation. Expected performance is within defined control limits. The ability of the process to achieve quantitative performance objectives is understood.

Processes that are significant contributors to overall process performance objectives are selected, and relevant measures are identified based on the standard set of organizational processes. Projects tailor the standard process (as in capability level 3) and establish the defined process. Additionally, however, projects select particular processes (or subprocesses) that are relevant to the established measures, and stabilize them by bringing them under statistical process control.

Measures and results from statistically controlled processes are stored in an organizational repository, aggregated, and analyzed to derive a quantitative understanding of the capability of the set of organizational standard processes, in relation to selected objectives and measures.

A main distinction between a defined process and a quantitatively managed process is the predictability of the process performance. With a quantitatively managed process, the process has been stabilized and future performance of the process can be predicted quantitatively. A defined process may only provide qualitative predictability. Note that the quantitatively managed process is driven by statistically controlling only those particular processes that are key to meeting established business objectives.

Level 4 Goal The process is institutionalized as a quantitatively managed process.

Level 4 Generic Practice

4.1 Stabilize Process Performance

Select measures key to meeting business objectives and bring processes relevant to those measures under statistical process control.

Notes: The purpose of this practice is to stabilize the performance of one or more processes that are determined to be key to meeting business objectives. Stabilization supports predicting the ability of the process to achieve the established business objectives.

Quantitative measures are determined (if not previously identified) and processes are selected that are relevant to those key measures. The measures can be tied to strategic goals of the organization, the particular needs and priorities of the customer, or the tactical needs of the implementing unit. Whereas business objectives for the planned and tracked process were determined at level 2, and for the defined process at level 3, those objectives did not necessarily need quantitative measures associated with them. At level 4, the objectives must be measured quantitatively.

The processes relevant to these measures are selected from the organization's set of standard processes. These are the processes chosen for stabilization.

Projects bring the selected processes under statistical control. A stable process shows no significant indication of special causes of process variation. In other words, any special causes of variation are analyzed and corrective action identified to remove them. A process is under statistical process control when its capability or range of expected results is defined by a specific range, and the limits of variation are predictable. The quantitatively managed process is stabilized so that it performs consistently within defined limits to achieve process outcomes.

If it is determined statistically that established quantitative business objectives will not be able to be satisfied, corrective action is taken such as changing the objectives or ensuring that relevant stakeholders have a quantitative understanding of, and have agreed to, the performance shortfall.

4.1 Stabilize Process Performance (continued)	*Relationship to other generic practices:* Measuring process performance is introduced at capability level 2 (GP 2.12). Measurement results are stored in an organizational repository as described in GP3.3. These results are used for process improvement and both the projects' quantitatively managed processes, and the organization's set of standard processes are improved using GP3.3. *Relationship to process areas:* Guidance regarding measurement and statistical process control is provided in Measurement and Analysis (PA 18).

Capability Level 5 - Optimizing

Level 5 Description

An optimizing process is a quantitatively managed (capability level 4) process that is changed and adapted to meet relevant current and projected business objectives.

Optimizing performance is enabled by quantitative feedback from the process and from piloting innovative ideas and technologies. A focus on widespread, continuous improvement permeates the organization. The organization establishes quantitative performance goals for process effectiveness and efficiency based on its business goals.

Improvements focus on introducing changes to those processes that are now under statistical control. These changes try to shift the expected (mean) performance value by removing common causes of process variation, or introducing new technology. Performance is optimizing as the organization strives to meet ever-stretching target levels set by the organization for performance excellence.

This is the highest achievement level from the viewpoint of process capability. The organization has established quantitative, as well as qualitative, goals for process effectiveness and efficiency, based on long-range business strategies and goals. Continuous process improvement toward achievement of these goals using timely, quantitative performance feedback has been established. Further enhancements are achieved by pilot testing of innovative ideas and planned insertion of new technology.

The primary distinction between a quantitatively managed process and an optimizing process is that the optimizing process is continuously improved by addressing common causes of variation. A quantitatively managed process is concerned with addressing special causes of process variation and providing statistical predictability for the results. Though the process may produce predictable results, the results may be insufficient to achieve the established objectives. An optimizing process is concerned with addressing common causes of process variation and changing the process to improve process performance (while maintaining statistical predictability) to achieve quantitative performance objectives.

Level 5 Goal The process is institutionalized as an optimizing process.

Level 5 Generic Practice

5.1 Pursue Process Optimization Pursue improvement to the performance of statistically managed processes based on business objectives, innovation, and removal of common problems.

Notes: The purpose of this practice is to introduce and evaluate improvements that change the process (i.e., shift the mean of the process performance) to achieve established business objectives. The improvements may be based on incremental organizational improvements or on innovations such as new technologies (perhaps as part of pilot testing). Improvements will typically be driven by the goals established at level 4, based on targets values that stretch beyond the control limits established at level 4.

Removing sources of common variation in the organization's standard processes is a continuation of special cause variation removal begun at level 4. Once disasters are prevented (special causes) then common variation can be squeezed out, and efforts to "move the mean" or expected outcome towards higher business value will be much more meaningful and results obvious, faster.

Relation to other generic practices: The information learned from managing individual projects is communicated back to the organization for analysis and deployment to other applicable areas using GP 3.3.

Relationship to process areas: Practices pertaining to technology changes and innovation are described in Innovation (PA 23). Measurement and Analysis (PA 18) practices provide guidance for measuring and analyzing process changes.

Chapter 5: Process Areas and Base Practices

Purpose of this chapter

This chapter contains the process areas and their base practices.

In this chapter

The following table provides a guide to the information found in the chapter.

Process Areas - Overview, Sources, and Format
PA 00 Integrated Enterprise Management
PA 01 Needs
PA 02 Requirements
PA 03 Design
PA 04 Alternatives Analysis
PA 05 Outsourcing
PA 06 Design Implementation
PA 07 Integration
PA 08 Evaluation
PA 09 Deployment, Transition, and Disposal
PA 10 Operation and Support
PA 11 Project Management
PA 12 Supplier Agreement Management
PA 13 Risk Management
PA 14 Integrated Teaming
PA 15 Quality Assurance and Management
PA 16 Configuration Management
PA 17 Information Management
PA 18 Measurement and Analysis
PA 19 *(reserved for future use)*
PA 20 Process Definition
PA 21 Process Improvement
PA 22 Training
PA 23 Innovation

Process Areas - Overview, Sources, and Format

Overview

The 23 process areas of the iCMM can be grouped into three categories: management processes, life cycle processes, and support processes. These groupings are depicted below.

Management Processes

Integrated Enterprise Management
Project Management
Risk Management Supplier Agreement Management Integrated Teaming

Life Cycle Processes

Needs		
Requirements		Deployment, Transition, Disposal
Design	Integration	
Design Implementation		Operation and Support
Evaluation		

Support Processes

Outsourcing	Alternatives Analysis	Measurement and Analysis	
Quality Assurance And Management	Configuration Management	Information Management	
Process Definition	Process Improvement	Training	Innovation

Figure 5.1 Process Areas of the iCMM

Overview (continued)

The management processes are used to set vision, goals, strategy, and direction. Management processes initiate, align, plan and track activities that will accomplish the objectives of the enterprise, organization, project, or team. They oversee the execution of the other processes in the model.

The life cycle processes are used to develop, maintain, transition, and operate a product or service in order to provide and sustain the services that a customer or stakeholder needs. These processes cover the typical life cycle of a product or service.

The support processes are used by other process areas when needed and contribute to the success and quality of all the processes.

In the sections that follow, each process area is presented. Although each process area is described separately, there are many relationships among the process areas, and these are explained in each process area description.

Process Area Sources

For version 1.0: The iCMM v1.0 process areas were derived and adapted from the following sources:

- Systems engineering: SE-CMM v1.0 [SE-CMM]
- Software engineering: SW-CMM v1.0 [SW-CMM 93]
- Acquisition: SA-CMM v1.01 [SA-CMM 96]

Process Area Sources (continued)

For version 2.0: The iCMM v2.0 process areas have been derived and adapted from the following sources:

- *Systems engineering, software engineering, acquisition:* FAA-iCMM version 1.0 [FAA-iCMM 97]
- *Organizational excellence*: President's Quality Award [PQA] and Malcolm Baldrige National Quality Award criteria [MBNQA]
- *Quality management*: ISO 9001:2000 [ISO 9001], ISO 9004:2000 [ISO 9004]
- *Systems engineering*: EIA/IS 731 [EIA/IS 731], ISO/IEC CD 15288 [ISO/IEC CD 15288], EIA-632 [EIA-632], CMMI-SE/SW/IPPD v1.02 [CMMI-SE/SW/IPPD]
- *Software engineering*: ISO/IEC 15504 [ISO/IEC TR 15504], ISO/IEC 12207 [IEEE/EIA 12207], CMMI-SE/SW/IPPD v1.02 [CMMI-SE/SW/IPPD]
- *Acquisition*: SA-CMM v1.02 [SA-CMM 99], CMMI-A (draft) [CMMI-SE/SW/A]
- *Integrated product development*: CMMI-SE/SW/IPPD v1.02 [CMMI-SE/SW/IPPD], IPD-CMM v 0.98 [IPD-CMM]

For version 1.0, mapping tables at the practice level were included as part of each process area description.

Due to the length of some of these tables, for version 2.0 all mapping tables are in Appendix D and its supplement.

Process Area Format

The general format of the process areas is shown in Figure 5-2.

The summary description contains a brief overview of the process area, including its purpose, major points addressed, goals, relationships, and a list of its base practices. Major source models and standards contributing to each process area are listed in the summary as well. However detailed mapping information is located in Appendix D.

A base practice summarizes a fundamental essential characteristic of performing a process that meets the intent of the process area, as expressed in its purpose. Each base practice is described in detail following the process area summary.

Although these PAs are described separately, they are interrelated and together contribute to the creation of sound processes across the enterprise.

Format

Figure 5-2 provides the general format of the process areas (PAs) and describes the content of each part.

PA #: PA Title	<PAxx, where xx is a unique integer associated with this PA: > <title describes the primary topic of the process area>	
Process Area Summary		
Purpose	The purpose of <PA Title> is <statement of contents and purpose of the PA>	
Major points addressed	<summarizing statements providing an abstraction of process area activities>	
Goals	<list of goals that summarize an expected state to be achieved if the purpose is met and the process area is successfully implemented, with mappings to base practices (BPs) that support achievement of each goal>	
Notes	<additional explanatory information>	
Relationships between this PA and other PAs	<notes on relationships between different PAs or other practices>	
Base practices list	BP #:	<tag> <base practice statement> .

BP # BP Title	<BPxx.yy where xx is the PA number, and yy is the base practice number> <phrase that captures primary topic or issue addressed by the base practice>
Statement	<imperative, verb-object statement that describes an essential element for attaining the purpose of the PA>
Description	<elaboration of the base practice statement and guidance that would be useful for those implementing the practice>
Typical Work Products	<list of generically named typical work products that are examples of what outputs could result from implementing the practice>
Notes	<elaboration on concepts and use of the base practice, conceptual examples, potential techniques, methods, guidance, etc. Content varies from BP to BP>
Additional Practice Guidance	<additional practices from source models and standards that relate to this base practice characteristic, but that may go beyond what is considered base or essential>

Figure 5-2. Process Area Format

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PA 00: Integrated Enterprise Management

Process Area Summary

Purpose
The purpose of the Integrated Enterprise Management process area is to establish the vision, mission, values, goals, and objectives of the enterprise; establish and maintain strategic plans to accomplish goals and objectives; initiate and monitor projects/activities to advance the business of the enterprise; evaluate performance relative to goals and needs; and enable individuals to function effectively by sharing a common understanding of enterprise vision, culture, and goals.

Major points addressed
Integrated enterprise management involves establishing, maintaining, and communicating the enterprise vision, mission, values, goals, and measurable performance objectives. The enterprise is aligned through unification of goals and consistency of actions among organizational units in support of these goals. Leadership is exercised through structures and mechanisms for decision making and for reinforcing values, expectations, and behaviors. Strategic plans are established for the major functions and operations of the enterprise and for establishment of performance goals linked to general goals and objectives. Supporting strategies at various organizational levels of the enterprise are established as appropriate. Action plans are established to accomplish those things that must be done for the strategy to succeed, and a performance management system is established. Projects are initiated, adequately resourced, and their progress monitored to confirm continuing contribution to achievement of objectives. Through integrated enterprise management, business and technical disciplines work collaboratively to accomplish enterprise-wide goals and performance objectives.

Goals
1. Vision, mission, values, performance goals and objectives are established, maintained, and communicated to all employees. *(BP 00.01, BP 00.02, BP 00.07)*
2. Strategies are developed and projects are launched that visibly support goal achievement. *(BP 00.03, BP 00.04)*
3. Projects are continued, changed, or terminated based on performance, within the capability of the organization, and with acceptable risk and potential benefit to the organization. *(BP 00.05, BP 00.06).*

Notes
In this process area, the term enterprise refers to one or more organizations with a set of goals and objectives to offer products and/or services. Thus the practices are applicable at an enterprise or organizational level, e.g., they may be applied to an entire top-level enterprise, a line of business, a directorate, a division, or any one or more organizations to which the above goals are germane. However, the process area pertains to management of a unit comprised of subordinate units that perform subsets of the

enterprise mission, goals, and objectives, and thus pertains to management above the project level.

Relationships between this PA and other PAs

The Needs process area (PA 01) provides customer and stakeholder input to the establishment of mission and strategy, and to strategic decisions regarding whether projects should be initiated or continued. The Innovation process area (PA 23) provides insights on new available technologies to support establishment of strategic vision. Integrated teams are created and empowered to meet organizational performance goals using the practices of Integrated Teaming (PA 14). The Integrated Enterprise Management process area activities provide an approval mechanism (e.g., approved statement of need) to initiate requirements development activities (PA 02). Project Management (PA 11) activities are initiated, continued, or terminated as a result of the Integrated Enterprise Management process area. The practices of Alternatives Analysis (PA 04) offer guidance on using a structured, disciplined decision process for selecting the areas or projects to be pursued. Projects provide information on performance to the Integrated Enterprise Management process area, and receive resources as a result of PA 00 practices. The work environment to support achievement of goals is improved and managed using the practices of Innovation process area (PA 23). The processes used in pursuit of goal achievement are defined and improved using the practices of Process Definition (PA 20), Process Improvement (PA 21), and Quality Assurance and Management (PA 15). Ways to establish the learning environment to support achievement of goals are described in Training (PA 22). The Risk Management process area (PA 13) provides guidance for assessing risks associated with products, services, and operations. The Measurement and Analysis process area (PA 18) supports measurement and analysis of performance goals. If goals are established pertaining to suppliers and/or partners, the Supplier Agreement Management process area (PA 12) provides input for performance evaluation.

Base practices list

BP 00.01 **Establish and maintain strategic vision**. Establish, maintain, and communicate a strategic vision that identifies long-term goals, values, performance expectations, and core activities.

BP 00.02 **Align to achieve the vision.** Align the enterprise to operate efficiently and consistently to achieve the vision.

BP 00.03 **Establish and maintain strategy**. Establish and maintain the enterprise strategic plans that identify business objectives to be achieved, areas of business to be pursued and their interrelationships, and the significant goals to be accomplished.

BP 00.04 **Develop and deploy action plans.** Establish, integrate, and deploy tactical action plans to accomplish strategic objectives.

BP 00.05 **Review performance.** Review performance relative to goals and changing needs across the enterprise.

BP 00.06 **Act on results of review.** Translate performance review findings into action.

BP 00.07 **Fulfill public responsibility**. Address the impacts on society of planned activities, products, services, and operations, considering regulatory and legal requirements and risks associated with products, services, and operations.

BP 00.01 Establish and maintain strategic vision

Establish, maintain, and communicate a strategic vision that identifies long-term goals, values, performance expectations, and core activities.

Description
Set organizational mission, values, performance expectations, core activities and long term goals that build and sustain an organization conducive to high performance, individual and organizational learning, empowerment, and innovation. Create directions, clear and visible values, and high expectations. Define product lines and core activities that support the organization's strategic vision. Communicate the vision to all elements of the organization, so that expectations are understood. Maintain the vision by evaluating its use and currency, and updating it as needed.

Typical Work Products
- strategic vision
- evaluations of the strategic vision
- long-term goals
- performance expectations
- values
- core activities
- product lines
- communication plan

Notes
Take into account and balance the needs of key stakeholders (customers, employees, suppliers, partners, Congress, the public, and the community) when establishing a shared strategic vision. Typical values include projecting a strong customer focus, encouraging improvement and innovation, enhancing customer value, including the value of people, and emphasizing integrated multidisciplinary teamwork at all organizational levels. Values should help guide all activities and decisions of the organization.

Articulate the vision in sufficient detail to provide criteria against which the organization's operations can be evaluated.

Performance expectations may relate to customer satisfaction, product and service performance, financial, marketplace performance, mission accomplishment, human resource results, supplier and partner results, operational performance, and organizational effectiveness.

Performance goals are targeted levels of performance expressed as measurable objectives against which actual achievement can be compared.

When defining product lines and core activities, consider the organization's strengths, weaknesses, the competition, potential market size, and available technologies. Defined product lines enable a more effective reuse approach and allow investments with high potential payoffs.

BP 00.02 Align to achieve the vision

Align the enterprise to operate efficiently and consistently to achieve the vision.

Description
Align the enterprise to support and operate consistently in pursuit of the vision. Establish infrastructure and leadership systems for decision making, priority setting, and reinforcement of values, expectations, and behaviors. Define empowerment and conflict resolution methods. Provide incentives to employees to contribute to the vision and strategy of the organization. Operate by action and example to achieve the vision.

Typical Work Products
- leadership system
- unified goals
- conflict resolution methods
- issue resolution methods
- organization charts
- guidelines for empowerment and decision making (for teams and individuals)
- management structure
- behavioral expectations
- monetary and non-monetary incentives

Notes
Alignment refers to unification of goals throughout the organization and consistency of processes, actions, information, and decisions among organizational units in support of these goals. Effective alignment requires common understanding of purposes and goals and use of complementary measures and information to enable planning, tracking, analysis, and improvement at several organizational levels. Alignment ensures that improvement and learning reinforce organizational priorities. Operating to achieve the vision requires clear understanding of the vision by all employees and other stakeholders.

Ensure the creation of strategies, systems, and methods for achieving the vision.

Effective approaches to high-performance work generally include cooperation between management and the workforce, cooperation among work units, self-managed/self-directed responsibility or empowerment, individual and organizational learning and skill building, flexibility in job design and work assignments, decentralized decision making, regular use of performance measures, and use of monetary and non-monetary incentives.

Emphasize integrated multidisciplinary teamwork at all organizational levels when applicable.

BP 00.03 Establish and maintain strategy

Establish and maintain the enterprise strategic plans that identify business objectives to be achieved, areas of business to be pursued and their interrelationships, and the significant goals to be accomplished.

Description
Develop a strategy and strategic plan. Identify strategic objectives with a timetable for accomplishing them. Use the practices of Alternatives Analysis (PA 04) to evaluate various options to determine how well they respond to factors most important to performance and mission accomplishment.

Typical Work Products
- strategy
- strategic direction
- strategic plans
- business objectives

Notes
Strategy development refers to the approach to a future-oriented basis for business decisions, resource allocations, and management. Various types of forecasts, projections, options, scenarios, or other approaches might be used to address the future.

Examples of key factors to consider in setting strategic direction include:
- customer and market/mission needs/expectations, including new product/service opportunities to meet needs
- customer satisfaction
- competitive and mission environment and capabilities, including use of new technology
- financial, societal, and other potential risks
- human resource capabilities and needs
- operational capabilities and needs, including resource availability
- supplier and/or partner capabilities and needs

Strategy may be built around any or all of the following: new products, evolution of existing product lines, services, and markets; revenue or mission growth; cost reduction; business acquisitions; new programs or missions; and new partnerships and alliances. Strategy might be directed toward becoming a preferred supplier, a low-cost producer, a market innovator, and/or a high-end or customized service provider. Strategy might depend upon or require developing different kinds of capabilities, such as rapid response, customization, market understanding, lean or virtual manufacturing, relationships, rapid innovation, technology management, leveraging assets, business process excellence, and information management.

Successful management of the overall enterprise requires looking at the organization as a whole and focusing on what is important to the whole enterprise. Risks associated with various strategies should be considered.

Strategic plans at lower organizational levels, as applicable, align with higher-level strategic plans.

BP 00.04 Develop and deploy action plans

Establish, integrate, and deploy tactical action plans to accomplish strategic objectives.

Description
Establish tactical action plans for each business area that identify the short-term objectives which contribute to achieving strategic objectives, and the projects or activities that will be undertaken to accomplish these objectives. Prioritize opportunities and ensure consistency with the strategic objectives. Identify expected outcomes and key performance measures and/or indicators for tracking progress relative to plans. Deploy the plans by initiating or continuing identified projects, allocating resources to ensure accomplishment of plans, and communicating action plans and performance measures/indicators. Assure alignment and consistency in order to provide a basis for setting and communicating priorities for ongoing activities.

Typical Work Products
- action plans
- tactical plans
- key performance measures and/or indicators
- allocated resources
- initiated, continued, or terminated projects
- agreements to supply services
- response to request for services
- response to request for proposal
- fiscal year plans

Notes
Activities include projects that provide products, services, and operations. Identify any multi-project interfaces that must be managed or supported by the project. This includes the use of enabling systems used by more than one project and the use of common system elements by more than one project.

Action plans refer to plans derived from strategic plans that make general strategies and goals specific so effective understanding and deployment are possible. Deployment of action plans requires analysis of overall resource needs and creation of aligned measures for all activities. The activities of the Measurement and Analysis process area (PA 18) support creating aligned measures.

Decisions made regarding initiation or continuation of projects and activities may result in the supplying organization responding to a request for services or a request for proposal.

Action plans may be developed to align achievement with periodic review and funding cycles, such as by fiscal year.

BP 00.05 Review performance

Review performance relative to goals and changing needs across the enterprise.

Description
Specify reporting requirements and review milestones that will govern performance review. Use key performance measures as part of regular review, and include employee feedback. Evaluate ongoing activities and projects to confirm that they are making progress towards achieving established goals, are complying with project directives, are being conducted according to established plans, and remain viable. Assess organizational health, competitive performance, and progress relative to changing needs. Review vision, mission, and alignment mechanisms.

Typical Work Products
- performance results
- review results
- project evaluations

Notes
Examples of criteria for evaluating project viability are the continuing need for the product or service, feasible and practical implementation, and acceptable investment benefits.

Performance refers to results that permit evaluation and comparison relative to goals, standards, or past results. Results may commonly address quality, efficiency, or effectiveness. Examples of organizational performance include operational, customer-related, financial, and mission/program results. Operational performance may pertain to cycle time, productivity, or waste reduction. Customer-related performance may pertain to reliability, on-time delivery, defect levels, service response time, customer retention, complaints, survey results, or changes in demand for products and services. Financial performance may pertain to asset utilization, asset growth, value added per employee, cost savings and cost avoidances. Mission/program performance may pertain to non-financial measures used to assess success in achieving purpose, goals, and objectives.

Supplier performance may also be reviewed to include measures of supplier- and partner-provided products and services used by the organization in developing final products and services, and services provided by contractor employees working within the organization but supervised by the contractor. The practices of the Supplier Agreement Management process area (PA 12) may provide input to this review.

BP 00.06 Act on results of review

Translate performance review findings into action.

Description
Translate performance review findings into priorities for improvement and deploy them throughout the organization and, as appropriate, to suppliers/partners and key customers to ensure organizational alignment.

Act to continue or redirect projects that are satisfactorily progressing or can be expected to progress satisfactorily by appropriate redirection. Where agreements permit, take action to cancel or suspend projects whose disadvantages and/or risks to the organization outweigh the benefits of continued investments.

Use organizational performance review findings and employee feedback to improve leadership effectiveness and the effectiveness of management throughout the organization.

Typical Work Products
- plans for improvement
- project redirection
- project cancellation or suspension

Notes
Prepare a plan for effecting improvements and changes, and assign and track the execution of the plan to change agents.

BP 00.07 Fulfill public responsibility

Address the impacts on society of planned activities, products, services, and operations considering regulatory and legal requirements and risks associated with products, services, and operations.

Description
An integral part of performance management and improvement is proactively addressing legal and regulatory requirements and risk factors. Addressing these areas means establishing appropriate measures and/or indicators for tracking during performance review. Public responsibility includes ensuring ethical business practices in all stakeholder transactions and interactions.

Typical Work Products
- results of regulatory or legal compliance reviews
- environmental improvements
- risk assessments

Notes
This practice also addresses sensitivity to issues of public concern whether or not these issues are currently embodied in law.

Examples of fulfilling public responsibility include community involvement in education, health issues, and environmental concerns.

Examples of impacts and risks associated with products, services, and operations include those related to health, safety, environment, and security.

Additional Practice Guidance
- Encourage employee community service
- Identify, support, and strengthen key communities

PA 01: Needs

Process Area Summary

Purpose
The purpose of the Needs process area is to elicit, analyze, clarify, and document evolving customer and other stakeholder needs and expectations, and to establish and maintain communication with the customer and other stakeholders throughout the life cycle to assure a continuous understanding of what will satisfy those needs.

Major points addressed
The success of an organization depends on understanding and satisfying customer and other stakeholder needs and expectations. The Needs process area focuses on customers and other stakeholders and on establishing, building and maintaining a relationship with them so current and future needs and expectations are proactively determined and understood. As products and services are provided to customers and used, their satisfaction is determined and monitored to ascertain if needs have been met and to provide input to the expression of new or evolving needs.

The Needs process area involves identifying the customer and other stakeholders and engaging them in an ongoing dialogue designed to understand current and future needs and expectations. These needs are analyzed in the operational environment and in relation to current capability to derive a concept of how a potential product or service will behave or operate when in use. Needs are expressed in a way that the customer and other stakeholders understand and that provides the basis for agreements between the customer and those supplying products and services to satisfy needs.

Customer and other stakeholder needs change over time. Organizations need to have a mechanism in place to incorporate such changes into current and future products and services.

Goals
1. A statement of customer and other stakeholder needs and expectations is established and maintained. *(BP 01.01, BP 01.02, BP 01.03, BP 01.04)*
2. The interaction of needed products and services with users in the intended environment is described. *(BP 01.02, BP 01.03, BP 01.04)*
3. Communication with the customer and other stakeholders is established and maintained. *(BP01.05, BP 01.06)*
4. Customer satisfaction with products and services is determined and monitored. *(BP 01.06)*

Notes
"Customer," as used here, denotes either a directly contracted customer or a customer surrogate who represents a particular market or user segment. The customer may be external or internal to the organization. Customers are purchasers or users of end products and services. When the term customer is used alone it usually refers collectively to "customers and other stakeholders". "Stakeholders" are individuals or organizations interested in the success of a product or service. Examples of stakeholders are customers, developers, operators, maintainers, unions, and management.

Relationships between this PA and other PAs
When the Needs PA establishes an expression of a new potential problem to be solved, further efforts to meet these needs are initiated according to the practices of the Integrated Enterprise Management process area (PA 00), which assures alignment of stated needs with enterprise goals, objectives, priorities, and resource availability. Needs so "approved" become input to the Requirements process area (PA 02).

As the problem to be solved becomes more clearly understood, the Needs process area is performed iteratively with the Requirements and Design process areas PA 02 and PA 03. The statement of needs and expectations is baselined and controlled using the practices of the Configuration Management process area (PA 16). It forms a basis for the development of requirements in the Requirements process area (PA 02). The practices of the Alternatives Analysis process area (PA 04) can be used to resolve conflicting needs and expectations. Customer satisfaction can be determined using practices of the Measurement and Analysis process area (PA 18). Customer satisfaction information is useful in measuring performance of a quality management system as described in Quality Assurance and Management (PA 15). It is also used as input for management review and action at the enterprise or project level (via Integrated Enterprise Management (PA 00) or Project Management (PA 11)). Products and services are validated in the operational environment to assure that customer needs and expectations are met using the practices of Evaluation (PA 08). Practices of the Integrated Teaming process area (PA 14) are useful in coordinating and communicating with the customer and other stakeholders. Demonstrations of potential new technologies as a result of the Innovation process area (PA 23) are ways of eliciting needs. Practices of Operation and Support (PA 10) are useful in establishing mechanisms for receiving customer satisfaction information.

Since this process area supports the dialogue between product and service providers and the customer, all other process areas will use it to communicate with the customer throughout the life cycle.

Base practices list

BP 01.01 **Identify customers and stakeholders:** Identify customers and stakeholders.

BP 01.02 **Elicit needs:** Elicit customer and other stakeholders' needs, expectations, and measures of effectiveness.

BP 01.03 **Analyze needs:** Analyze needs and expectations in the context of the intended operational environment.

BP 01.04 **Establish and maintain a statement of need:** Establish and maintain a statement of customer and other stakeholder needs and expectations that is understood and agreed upon by the customer and other stakeholders.

BP 01.05 **Communicate with customers:** Communicate and interact with customers and other stakeholders throughout the life cycle to assure a common understanding of the status and disposition of needs, expectations, and measures of effectiveness.

BP 01.06 **Determine customer satisfaction:** Determine customer satisfaction with products and services.

BP 01.01 Identify customers and stakeholders

Identify customers and stakeholders.

Description
Identify customers and other interested parties, individual stakeholders, or stakeholder classes who have an interest in the problem to be solved. These may include, but are not limited to, users, supporters, developers, producers, testers, trainers, maintainers, disposers, acquirer and supplier organizations, regulatory bodies, unions, members of society, and others who may be affected by, or may affect, the potential product or service throughout its life cycle. Where direct communication is not practical, representatives or designated proxy or surrogate stakeholders are selected. Criteria are determined and used for customer and other stakeholder selection when appropriate. Potential stakeholders are also identified. The list of customers and stakeholders is likely to evolve as the context of the problem becomes more fully understood and throughout the different phases of the life cycle.

Typical Work Products
- list of customers or customer groups
- list of market segments
- list of stakeholders or stakeholder classes
- list of interested parties
- criteria for customer and stakeholder selection
- roles and responsibilities of customers and stakeholders
- demographics of people who would operate, maintain, and support the needed product or service

Notes
Interested parties may include people in the organization, owners/investors, shareholders, individuals or groups including the public sector that have an interest in the organization, suppliers and partners, the community, and the public affected by the organization.

Surrogates may include, for example, customer relations, marketing, or human factors engineering parts of the organization.

Statistical sampling may be used to identify a representative group when there is a large number of customers or stakeholders.

Customers and other stakeholders are the sources for elicitation of needs, the sources of product and service satisfaction measures, and the contacts for communication throughout the life cycle. Customers determine whether products and services are satisfactory in meeting their needs (see also BP 01.06).

BP 01.02 Elicit needs

Elicit customer and other stakeholders' needs, expectations, and measures of effectiveness.

Description

Frequently, customer and other stakeholder needs and expectations are poorly identified or in conflict. Both customer and supplier satisfaction depend critically on the clear identification of customer and other stakeholder needs, expectations, and limitations. An iterative process of eliciting, listening, and learning is used throughout the life cycle to accomplish this. Elicitation involves discovering needs that the customer may not immediately recognize or express. Needs may be uncovered through analysis of projected service capability shortfalls or by demonstration of potential new technologies or research results. Sources of needs, assumptions, rationale, and the value placed on satisfaction of the need are recorded. Measures of effectiveness, such as expected technical performance or operational suitability, are identified so that customer satisfaction or acceptance of products or services provided can be measured and assessed accordingly. Environmental, regulatory, legal, and other constraints that may be external to the customer must also be identified when establishing the set of needs.

Typical Work Products

- needs, expectations, and constraints
- technical performance measures
- performance measures
- human-system performance measures
- measures of suitability
- parameters to evaluate effectiveness
- trouble reports
- problem reports
- issues or conflicts
- assumptions, sources of needs, and value placed on satisfaction of need
- justification and rationale for needs
- satisfaction criteria
- suitability and effectiveness attributes

Notes

Needs may be identified through analysis of supply and demand of services, and identification of possible capability shortfalls. Needs may be stimulated from customers by such means as demonstrating new technology, new opportunities, or improved ways for solving operational problems. Results of human factors engineering analyses, studies, or research can be used to elicit needs. Needs may be established from mandates. Operational and customer satisfaction data are sources for current and evolving needs.

Needs may include staff expectations for recognition, work satisfaction, competencies and development of knowledge.

Measures of effectiveness may be thought of as satisfaction criteria and they may include indicators of customer satisfaction, or financial and other results that satisfy the identified needs and expectations of owners and investors. Sometimes actual values for measures are identified early on, but more typically specific values are derived when formalizing needs into requirements using the practices of the Requirements process area (PA 02).

A variety of eliciting, listening and learning strategies may be used, depending upon the type and size of the organization and other factors. Some examples are:

- rapid innovation and field trials of products and services to better link research and development and design to market needs and/or mission requirements
- close tracking of technological, competitive, societal, environmental, economic, demographic and other factors that may bear upon customer needs, expectations, preferences, or alternatives
- seeking to understand, in detail, customers' value chains and how they are likely to change
- use of critical incidents, such as accidents or natural disaster, to understand key service attributes from the point of view of customers
- interviewing former customers to determine the factors they use in their purchase decisions; and won/lost and/or comparative analysis relative to competitors and/or similar organizations
- post-transaction follow-up contacts with customers
- analysis of major factors affecting key customers
- research, studies, and analyses of customer's performance and system performance with typical customers

Examples of techniques to elicit needs include:

- Joint Applications Design (JAD) meetings
- technology demonstration
- presentation of research, study, and analysis results
- analysis of customer satisfaction data
- review of trouble reports
- interface control working groups
- technical control working groups
- focus groups
- interim program reviews
- questionnaires, interviews, operational scenarios obtained from users
- prototypes, models, and simulations
- brainstorming
- Quality Function Deployment (QFD)
- market surveys
- beta testing
- extraction from sources such as documents, standards, or specifications
- observation of existing systems, services, environments, and workflow patterns
- information modeling
- storyboards
- use cases
- business case analysis
- reverse engineering (for legacy products)

BP 01.03 Analyze needs

Analyze needs and expectations in the context of the intended operational environment.

Description
The operational context for the customer need is described including external entities, interactions, boundaries, and properties of the application domain. Then the needed product or service is described in this context to understand its purpose and expected behavior. Analyses are performed to determine what impact the intended target environment will have on the ability to satisfy the customer's needs and expectations. Feasibility, mission needs, cost constraints, potential market size, human performance, safety, security, environmental needs, etc., must be taken into account, depending on the product or service context.

Operational scenarios are developed to depict events expected to occur when using the product or service to achieve a goal. By reviewing the needs in the context of operational scenarios, implicit and unstated needs are made explicit. Initial operational concepts are developed to describe how the potential product or service will be used in the operational environment, how it will affect users and maintainers, and the general desired capabilities it should possess. Operational scenarios and concepts express what the customer expects to be true when the products and services are utilized. As the problem becomes more fully understood, operational concepts are refined with the stakeholders to provide a more detailed view of the interaction of the product or service, the user, and the environment that satisfies the operational need. New needs may be discovered through this refinement process. As part of this activity, parameters that will be used to evaluate effectiveness and suitability are refined. Understanding the operational context is critical, since products and services are validated based on their use in the intended environment.

Typical Work Products
- operational concept
- installation, maintenance, support, and disposal concepts
- new needs
- refined needs
- additional issues
- use cases
- context diagrams
- operational scenarios
- usability parameters
- user interaction sequences
- maintenance operational sequences
- simulations
- external interfaces
- system cost objectives
- effectiveness, suitability, usability and technical parameters

- market-segment description
- storyboards

Notes
It is often necessary to help the customer formulate complete concepts. The customer's needs and expectations should be probed to ensure they are adequately understood.

Expression of operations, logistics, support, maintenance, and training considerations are ways to capture needs.

Define use sequences to identify a complete set of services for different operational scenarios and environments. Analyze the social and organizational influences on users, operators, and maintainers that could affect use or constrain design. Analysis includes identifying and studying the activities that users perform to achieve product or service goals, the relevant characteristics of end-users (e.g. expected training, degree of fatigue), the physical environment (e.g. available light, temperature) and any equipment to be used (e.g. protective or communication equipment). Analyze the operation of the system in its intended environment to identify needs and expectations that may not have been formally identified by any of the stakeholders, for example, legal, regulatory and social obligations.

Analyze the ability of humans to interact with the product or service. Determine a set of usability parameters, analyzing human performance and human-system interactions. Specify criteria for acceptable ease of use, efficiency of use and the extent to which the operator or user errors need to be prevented or mitigated. Use applicable standards and accepted professional practices in order to define:
- physical and cognitive capabilities and limitations
- work place, environment and facilities
- normal, unusual, and emergency conditions
- operator and maintainer training
- integration of human performance into system design and operations
- safety critical human actions and how the consequences of error are addressed
- opportunities for automation to enhance the performance of operators

A detailed operational concept may include scenarios that describe the environmental conditions, usage rates, expected inputs (stimuli) and outputs (responses).The behavior of the product or service may be organized by states (e.g., initial and final), modes of operation, and time sequences. Scenarios describe the behavior that meets the customer’s operational need, and any exceptional behavior that may be caused by the environment, errors, or faults.

Examples of methods used to analyze needs include:
- Quality Function Deployment (QFD)
- early comparability analysis
- trade studies

- mathematical techniques (design of experiments, sensitivity analysis, timing, sizing, Monte Carlo simulation)
- prototypes
- customer value determination cycle

Examples of activities to develop a detailed operational and maintenance concept include:

- conduct a task analysis
- analyze historical usage and performance
- conduct research on operations and maintenance procedures
- evaluate training costs and results
- develop a prototype of the user interface and capture descriptions of user interaction
- develop a system simulation or prototype

Additional Practice Guidance

- Identify needs and expectations that could affect safety. These include methods of operations, maintenance, and support, health and safety, threats to property and environmental influences. Applicable standards and accepted professional practices are used.
- Analyze all applicable areas of security, including information, physical, procedural, communications, computers, and emissions. Identify functions that could impact the security of the product or service, including access and damage to protected personnel, properties and information, compromise of sensitive information, and denial of approved access to property and information. Identify needed security functions, including mitigation and containment, referencing applicable standards and accepted professional practices where mandatory or relevant.
- Analyze and identify stakeholder needs and expectations that relate to other critical performance properties or attributes.

BP 01.04 Establish and maintain a statement of need

Establish and maintain a statement of customer and other stakeholder needs and expectations that is understood and agreed upon by the customer.

Description
The various needs and operational views from the customer and other stakeholders are consolidated and reviewed for consistency, unambiguity, clarity, and completeness. Any missing information is obtained, needs are prioritized, conflicts are resolved, and the results are documented and baselined as the recognized statement of needs, expectations, and constraints. The statement of need should identify the needed operational or functional capability, goals, objectives, purpose of the potential product or service, rationale, relationship to enterprise goals and objectives, sources, expected benefits, constraints, timeframe, and criticality. The statement of need may include needs and expectations with regard to validation. The customer and other stakeholders validate this statement by concurring that the description of needs, results of analysis, and operational views are expressed correctly and that they adequately capture and address their needs and expectations. The statement of need is expressed in terms the customer understands, and is used to derive requirements for products and services that are traceable back to customer needs. This practice also assures that the statement of need is maintained and continues to represent changes that may result from new conditions or changing technology. The statement of need forms the basis for validating products and services, to confirm that they fulfill stated needs in the operational environment.

Typical Work Products
- statement of need
- validated needs
- operational views
- definition of customer terms
- mission need statement
- problem statement
- agreements and commitments
- methods of validating needs
- description of operational problem
- revalidated needs

Notes
Conflicts that may have been identified during elicitation are resolved, and needs are prioritized by the customer. The practices of the Alternatives Analysis process area (PA 04) can be used to resolve conflicts. Terminology used in describing needs and expectations is defined. Throughout the life cycle, the needs statement may be revisited and revalidated to assure it still represents the customers needs and expectations, and has not been affected by any environmental or technology changes that may have occurred. Appropriate change control procedures should be followed to change the statement of need (see PA 16 Configuration Management).

Examples of forums to obtain customer concurrence include:

- working groups
- formal program reviews
- payment milestones
- in-process reviews
- status meetings
- weekly telephone conferences
- focus groups
- beta tests

Additional Practice Guidance

- Prioritize stakeholder needs, expectations and constraints.
- Review, coordinate, and deconflict stakeholder needs and constraints.
- Determine or project key product/service features and their relative importance to customers.
- Analyze the complete set of elicited needs to resolve conflicts and any contradictory, ambiguous, inconsistent, incongruous or unverifiable needs. Identify needs that cannot be realized or are impractical to achieve.
- Communicate the analyzed needs to applicable stakeholders and ensure that the needs and expectations have been adequately captured and expressed. Establish that the statements of need are comprehensible to all originators, that they are expressed correctly and that the resolution of conflict has not corrupted or compromised stakeholder intentions.
- Record the stakeholder needs in a form suitable for management through the life cycle and beyond. These records retain changes of need and their origin throughout the system life cycle, they act as an information source for trade-off decisions and, in the case of persistent stakeholder needs, form a source of knowledge for requirements for subsequent systems.
- Review the statement of need at key decision times in the life cycle to ensure that account is taken of any changes of need.

BP 01.05 Communicate with customers

Communicate and interact with customers and other stakeholders throughout the life cycle to assure a common understanding of the status and disposition of needs, expectations, and measures of effectiveness.

Description

The success of an organization depends on understanding and communicating with the customer, and building relationships with the customer. Mutually beneficial customer interaction mechanisms need to be established and maintained to assure communication regarding issues affecting the customer and the product or service provider. Such mechanisms apply to communication during product and service development, and during operation and use. Communication and interaction with the customer are essential while analyzing customer needs, deciding on general approaches, and considering/negotiating cost, schedule, and feature tradeoffs. Regular interaction reconfirms commitment, provides visibility into status and issues, and assures the customer that needs are being met. It also helps build trust, confidence, and customer loyalty. Communication continues throughout the life cycle as needs evolve and requirements change. When products and services are in use, the customer must know how to receive information and assistance, and how to provide comments, problem reports, or complaints. Customers should receive notification of problems affecting the product or service, status information on problems reported, and product and service release schedules. Customer interaction is important in assigning severity levels to problem reports. Building customer relationships may include development of partnerships or alliances.

Typical Work Products

- customer communication process
- problem reporting mechanism
- technical interchange minutes
- records of interactions with customers
- agreements with customers and other stakeholders
- memos of understanding
- memos of agreement
- prototypes
- requirement traceability tables
- product and service status and release schedules

Notes

Examples of arrangements for communicating with the customer and other stakeholders include:

- working groups
- quality review meetings
- shared expectations meetings
- customer site visits

- formal program reviews
- payment milestones
- in-process reviews
- status meetings
- weekly telephone conferences
- focus groups
- beta tests

Additional Practice Guidance

- Inform stakeholders on a regular basis about the status and disposition of needs, expectations, or measures of effectiveness.
- Involve stakeholders in the process of requirements development.
- Capture records of communications with stakeholders relative to requirements trade studies and allocations.

BP 01.06 Determine customer satisfaction

Determine customer satisfaction with products and services.

Description
Determine customer satisfaction and dissatisfaction with current and past products and services to improve current products and services, address current and projected needs, anticipate future needs, and develop new opportunities. Customer satisfaction data can help determine when a capability shortfall may develop, or help define an emerging need. Use measurements to capture actionable information. Measurements of satisfaction of needs and expectations are inputs for determining new needs, and for management review and action related to improvement of products and services. Determine satisfaction of other stakeholders as appropriate.

Typical Work Products
- customer survey results
- customer feedback
- customer and stakeholder satisfaction measures and levels
- projected needs
- new opportunities
- problem reports
- trouble reports
- results of validation

Notes
Customer satisfaction and dissatisfaction might be determined in any or all of the following: surveys, formal and informal feedback from customers, use of customer account data, trouble reports, complaints, research, studies, and analyses.

Customer satisfaction measurements might include qualitative and quantitative performance measures using both objective and subjective data. Such data might include both a numerical rating scale and descriptors for each unit in the scale. Classifications of criticality of problems may be developed and agreed upon with the customer. Effective (actionable) customer satisfaction measurements provide reliable information about customer ratings of specific product, service, and relationship features, the linkage between these ratings, and the customer's likely future actions—repurchase and/or positive response or referral. Product and service features might include overall value and price.

Customer satisfaction and dissatisfaction results and information on product/service measures that contribute to customer satisfaction or dissatisfaction should be used in the context of Measurement and Analysis (PA 18). These latter measures might include trends and levels in performance of customer-desired product features or customer complaint-handling effectiveness, such as complaint response time, effective resolution, and percentage of complaints resolved on first contact.

A complaint management process may involve a customer advocacy program.

For customer information to be actionable, tie the information to key business processes, and determine cost/revenue or program effectiveness implications for setting improvement priorities.

Complaint aggregation, analysis, and root cause determination should lead to effective elimination of the causes of complaints and to priority setting for process, product, and service improvements. Effective complaint management includes sharing information throughout the organization so everyone can learn from these customer transactions.

A key aspect of customer satisfaction determination is satisfaction relative to competitors and competing or alternative offerings. Such information might be derived from comparative studies or from independent studies. The factors that lead to customer preference are of critical importance in understanding factors that drive markets and potentially affect longer-term competitiveness.

Additional Practice Guidance

- Monitor information on customer satisfaction and/or dissatisfaction as one of the measurements of performance of the quality management system. The methodologies for obtaining and using this information shall be determined.

PA 02: Requirements

Process Area Summary

Purpose
The purpose of the Requirements process area is to develop requirements that meet customer needs; analyze the product, service and other requirements; derive a detailed and precise set of requirements; and manage those requirements throughout the life cycle.

Major points addressed
The Requirements process area involves translating customer needs, expectations, and operational concepts into a statement of requirements. Requirements are derived and analyzed to ensure they satisfy established quality criteria including traceability, completeness, feasibility, verifiability, and unambiguity. This may occur iteratively to successively lower levels of requirements detail.

An agreement with the customer on requirements for the product or service is established and maintained. This agreement covers technical and non-technical requirements and acceptance criteria. It forms the basis for estimating, planning, performing, and tracking activities throughout the life cycle that satisfy customer requirements.

The impact of changes to requirements on cost, schedule, risk, and other related factors is understood and agreed to by key stakeholders. Requirements are baselined, controlled, traced, and used in plans, and as a basis for products, activities, and agreements throughout the life cycle.

Goals
1. Requirements are developed from customer and other stakeholder needs. *(BP 02.01, BP 02.02, BP 02.03, BP 02.04, BP 02.05)*
2. Requirements satisfy established quality criteria including unambiguity, completeness, traceability, feasibility, and verifiability. *(BP 02.06, BP 02.09)*
3. All requirements information is recorded in a baseline that is maintained and controlled throughout the life cycle *(BP 02.07, BP 02.08, BP 02.09)*
4. Plans, products, activities, and agreements are checked for consistency with requirements, and any inconsistencies are identified for correction. *(BP 02.08, BP 02.09)*

Notes
Requirements form the agreed-upon basis for developing a product or providing a service, and for managing products and services through all life-cycle phases. Requirements are used as a documentation of expectations, as a baseline for designing a solution, and as proof of compliance of the provided product or service. In addition, requirements changes must be able to be incorporated at appropriate times in the life cycle.

Relationships between this PA and other PAs

The Requirements process area is initiated when a statement of need is approved for investigation according to practices of the Integrated Enterprise Management process area (PA 00). The Requirements process area elaborates the approved statement of needs and expectations and the operational view of needed products or services that was developed in the Needs process area (PA 01). The more detailed and precise set of requirements developed in the Requirements process area forms the basis for the Design process area (PA 03). These three process areas (PA 01, PA 02, and PA 03) may be performed iteratively as the solution becomes more completely described. When conflicts or issues are identified with customer or derived requirements (e.g., requirements are not verifiable per Evaluation (PA 08)), the issues may be referred to the practices of Needs (PA 01) or Alternatives Analysis (PA 04). Evaluation practices (PA 08) can be used to assure requirement documents (as incremental work products) meet established criteria. Project Management practices (PA 11) use requirements as the basis for managing the project throughout the life cycle, and any inconsistencies between requirements and plans, products, activities, and agreements are identified for corrective action using Project Management and Risk Management (PA 13) practices. Provided products or services are evaluated against requirements using the practices of Evaluation (PA 08). Configuration Management practices (PA 16) provide the change control necessary to manage requirements baselines. Requirements form the basis for the solicitation package prepared during Outsourcing (PA 05), and become agreements and contractual obligations managed using the practices of Supplier Agreement Management (PA 12). The practices of Integrated Teaming (PA 14) provide the collaborative decision-making forum and integrated coordination and communication useful in executing Requirements practices. The Requirements process area provides for requirements documentation, quality, and traceability throughout the product or service life cycle. Requirements analysis is performed on requirements change requests generated by the activities of Operation and Support (PA 10).

Base Practice List

BP 02.01 **Identify functional and performance requirements:** Identify functional and performance requirements, and required product or service attributes, including any requirements pertaining to safety, security, human factors, or other specialized areas.

BP 02.02 **Identify nonfunctional requirements and constraints**: Identify requirements and constraints pertaining to processes used in providing the required product or service, and pertaining to the context or intended operational environment.

BP 02.03 **Identify key requirements:** Identify key requirements that have a strong influence on cost, schedule, functionality, risk, or performance, or that are critical to customers and other stakeholders.

BP 02.04 **Derive requirements:** Derive requirements that may be identified as necessary implications of stated functional, nonfunctional, interface, or other derived requirements.

BP 02.05 **Identify external interface requirements:** Identify the requirements associated with external interfaces to the system, product, or service.

BP 02.06 **Analyze requirements:** Analyze requirements to ensure that they satisfy established quality criteria including unambiguity, completeness, traceability, feasibility, and verifiability.

BP 02.07 **Record and baseline requirements:** Record, approve, baseline, and place under change control all requirements, derived requirements, derivation rationale, traceability, and requirements status.

BP 02.08 **Analyze and resolve requirements change requests**: Analyze all requirements change requests for impact on the product or service and, upon approval, incorporate the approved changes into the requirements baseline.

BP 02.09 **Maintain consistency and traceability:** Maintain traceability among requirements and between requirements and plans, work products, and activities, initiating corrective action if inconsistencies are identified**.**

BP 02.01 Identify functional and performance requirements

Identify functional and performance requirements, and required product or service attributes, including any requirements pertaining to safety, security, human factors, or other specialized areas.

Description
Derive from the operational scenarios and concepts developed in the Needs process area (PA 01) a precise technical description of each function that the solution must provide, and how well each function must be performed. Performance requirements include such considerations as service levels, capacity, response time, throughput, sequencing of time-critical functions, and frequency of use. Product performance requirements must recognize human performance assumptions and constraints identified during operational analysis (see PA 01). Identify required functional attributes that the product or service must possess and their required levels for factors such as reliability, maintainability, availability, survivability, and interoperability. Consider product attributes required across the full life cycle such as transportability, installability, adaptability, operability, maintainability, sustainability, supportability and disposability. Include requirements such as those pertaining to safety, security, human factors, health factors, or other specialized areas as applicable. Decompose required functions into subfunctions as required to express or represent the products or services that must be provided.

Typical Work Products
- functional requirements
- operational requirements
- technical requirements
- performance requirements
- safety requirements
- security requirements
- human factors requirements
- data storage and retrieval requirements
- functional architecture
- logical solution
- requirements document

Notes
Functional and performance requirements may be described as an arrangement of required functions, their subfunctions, and interfaces that defines sequencing, control or data flow conditions, and performance. This is sometimes called a functional architecture or a logical solution. A variety of approaches is available, as well as a variety of representations.

Safety requirements may pertain to the safe functioning of the product or service, safe operation by humans, environmental issues, property safety, or health. Security requirements may pertain to protection of information, personnel, equipment, data and

material. Required security functions may include access protection, intrusion detection, containment and recovery. Hazardous or potentially threatening situations identified during operational analysis are expressed in terms of required risk reduction. The practices of the Risk Management process area (PA 13) support the development of safety and security requirements.

Especially early in the life cycle, there is a tendency to underestimate the importance of the requirements that impact on or result from human performance and system acceptability considerations. In order to achieve the desired user-centered design and development goals that will contribute to system effectiveness and suitability, appropriate emphasis must be placed on human resource and human-system performance requirements. Analyze human-system performance interfaces (see also BP02.05) and human-system performance requirements related to integrating the user, operator, and maintainer into the system's expected performance levels, and related to such system attributes as cognitive workload, staffing levels and personnel attributes, training, special tools and procedures, safety and health, communications, CHI, and other human factors.

Measures of effectiveness, satisfaction criteria, and indicators of importance to the customer and other stakeholders were identified and captured in the Needs process area (PA 01). For those measures relating to the performance, effectiveness, suitability, or functional behavior of the intended product or service, actual required values or ranges of values for these technical indicators are identified in this base practice if they were not specified earlier.

Additional Practice Guidance

- Analyze and quantify functionality required by users.
- Analyze and quantify functionality indicated by stakeholder requirements.
- Consider the sequencing of time-critical functions both initially and subsequently during system component development.
- Partition requirements into groups, based on established criteria (such as similar functionality, performance, or coupling) to facilitate and focus requirements analysis.
- Allocate requirements to functional partitions or objects, if appropriate.
- Analyze and define safety considerations, including those relating to methods of operation and maintenance, environmental influences and personnel injury. Each safety function and its associated safety integrity, expressed in terms of the necessary risk reduction, is specified.
- Analyze security considerations including those related to compromise and protection of sensitive information, data and material. The security related risks are defined, including, but not limited to, administrative, personnel, equipment, physical, computer, communication, network, emanations and environmental areas using applicable security standards.
- Analyze and specify system requirements and functions that relate to critical qualities other than health, safety and security.

BP 02.02 Identify nonfunctional requirements and constraints

Identify requirements and constraints pertaining to processes used in providing the required product or service, and pertaining to the context or intended operational environment.

Description
Identify requirements and constraints on the processes to be used to provide the service. These may include cost constraints reflecting the value of the solution, schedule requirements reflecting when the product or service is needed, or requirements to comply with specific standards. Although constraints on the solution are to be minimized, there may be environmental or other regulations, laws, mandates, or organizational policy that would constrain solution providers in various ways, for example to follow certain practices or standards, to use certain technologies, or to maximize reuse.

Identify requirements associated with providing and accepting the solution, such as requirements for product and service evaluation, quality assurance, and configuration management. Identify requirements associated with deployment, transition, installation, training, staffing, facilities, packaging, handling, logistics, transportation, facilities, equipment, and disposal.

Include facts, assumptions and constraints that pertain to the context and intended environment for the required product or service. These may include human factors constraints and limitations, or specific safety or security constraints.

Typical Work Products
- nonfunctional requirements
- environmental assumptions and constraints
- cost constraints
- scheduling requirements
- programmatic requirements
- legal and regulatory requirements
- transition requirements
- supportability requirements
- design constraints
- process requirements
- evaluation requirements
- human factors constraints and limitations
- human resource (e.g., staffing, training, personnel experience and abilities) constraints
- human performance objectives
- logistics requirements

Notes
Nonfunctional requirements are sometimes called process requirements, programmatic requirements, or nontechnical requirements.

Additional Practice Guidance
- Identify and manage non-technical requirements concurrently with operational, functional, support, maintenance, and disposal requirements.
- Specify the requirements for enabling systems used during maintenance of the system
- Define the number and type of replacement system elements to be stored, their storage locations and conditions, their anticipated replacement rate, their storage life and renewal frequency.
- Specify skill and personnel levels required to effect repairs and replacements.

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BP 02.03 Identify Key Requirements

Identify key requirements that have a strong influence on cost, schedule, functionality, risk, or performance, or that are critical to customers and other stakeholders.

Description
In analyzing requirements, requirements are often identified that have an especially strong influence on the cost, development schedule, risk, or performance of a product or service. The total set of requirements is screened for potential key requirements. A cost-benefit analysis is then performed on these requirements using the process areas Alternatives Analysis (PA 04) and Design (PA 03). The results of analyzing these requirements are reviewed with the customer. Key requirements that show a relatively low benefit-to-cost ratio, high risk, or long development schedule are candidates for negotiation with the customer using practices of the Needs process area (PA 01). Key requirements are a primary input to the activities of the Risk Management process area (PA 13). Critical performance parameters may be tracked during product and service development (see Project Management PA 11).

Another set of key requirements includes features that are especially important to customers such as critical operational issues, price, value, delivery, and customer or technical support. Establish the precedence, priority, and criticality of requirements.

Identify volatile requirements that are likely to change, as well as those with relatively high stability.

Typical Work Products
- key requirements issues
- key design drivers
- critical operational issues
- benefit-to-cost sensitivity analyses for key requirements
- critical performance parameters
- technical performance measures
- proposed requirements changes to resolve with the customer
- requirements priorities and criticality

Notes
An example activity is to identify performance requirements that are near the state of the art. Key requirements may be mapped to critical issues, and critical performance levels may be associated with measures of effectiveness or satisfaction criteria identified during needs elicitation activities (see Needs (PA 01)). Identified key requirements may be used for tracking technical progress. Requirements may be key because of their impact on the critical path.

Key requirements would typically include those reflecting needs that the customer identified of highest priority, importance, or value in the statement of need, or those identified as non-negotiable.

Additional Practice Guidance

- Identify key stakeholder requirements and constraints that have a strong influence on cost, schedule, functionality, risk, or performance.
- Record system requirement decisions that have a significant effect on cost, technical or schedule performance and the rationale for the decisions.
- Determine or project key product/service features and their relative importance to customers.

BP 02.04 Derive requirements

Derive requirements that may be identified as necessary implications of stated functional, performance, nonfunctional, interface, or other derived requirements.

Description
Derived requirements are those requirements that are explicitly identified or discovered as necessary implications of other stated requirements. A high-level requirement's derived requirements "represent" the high-level requirement, so that derived requirements can be implemented to satisfy the higher-level requirements.

Derive those requirements necessary to ensure that the developed product can be produced economically, operated reliably, and maintained cost effectively. A producibility analysis can be performed to identify any critical or production engineering requirements that constrain the design (see Risk Management (PA 13)). Requirements and constraints are also derived from the operational concept and mission need to ensure that the customer needs are met by providing for reliable and cost-effective operation and maintenance. These new requirements are included in the applicable requirements documentation.

Typical Work Products
- derived operational requirements
- derived performance requirements
  - producibility-related design constraints
  - reliability goals for program phases
  - quantified maintainability requirements
  - operation-related derived requirements
- functional performance budgets

Notes
Higher-level requirements from which requirements are derived may be derived requirements themselves, e.g., requirements derivation is performed iteratively as necessary.

Example activities include:
- Produce derived requirements necessary to render requirements testable.
- Assess system requirements for derived requirements relating to the operational environment.
- Produce rationale for derived requirements.

Examples of requirements related to production and operations include:
- mechanical or electrical design-related requirements to ensure systems can be manufactured efficiently at low risk
- quantified maintainability requirements that are necessary to allocate to components
- derived requirements by program phases that are necessary to meet the mission need

- operational requirements that address educational and skill levels of system operators/users

Additional Practice Guidance

- Derive, from the system and other (e.g., environmental) requirements, requirements that may be logically inferred and implied as essential to system effectiveness.

BP 02.05 Identify external interface requirements

Identify the requirements associated with external interfaces to the system, product, or service.

Description
External interface requirements define the way the product or service must interact with its intended environment. This includes interfaces with people who are users, operators, or maintainers; with the physical environment; and with other systems, products, or services. Requirements may pertain to interfaces with test equipment, transportation systems, or power or communication systems. External interface requirements establish expected system behavior at its boundary.

Specify criteria for acceptable ease of use, efficiency of use, and the extent to which the solution must prevent or mitigate operator, maintainer, or user error. Identify interoperability requirements for interfaces with other systems.

Typical Work Products
- interface requirements
- interface control document (ICD)
- user interface requirements
- interface requirements documents
- computer-human interface (CHI) requirements

Notes
External stimuli and inputs identified in operational scenarios (see BP 01.03) are candidates for external interfaces. The identification of external interfaces is facilitated by the development and understanding of the detailed operational concept (see BP 01.03). In addition, the identification of external interfaces forms the basis for derived external interface requirements, as well as many derived functional and performance requirements.

Examples include:
- Identify the input and output requirements and attributes for each user interface function.
- Identify the input and output data of all external systems that must interface to the subject system.
- Identify the physical requirements of all external system interfaces.
- Identify physical mounting requirements
- Identify operator stimuli and control points.
- Identify signal and control structures.
- Identify interfaces to the environment.

BP 02.06 Analyze requirements

Analyze requirements to ensure that they satisfy established quality criteria including unambiguity, completeness, traceability, feasibility, and verifiability.

Description
The purpose of this practice is to ensure that all the requirements that are developed, including derived requirements, satisfy established quality criteria including unambiguity, completeness, traceability, feasibility, and verifiability. Criteria are selected as relevant to the project or organization. Examples of other quality attributes are correctness, consistency, clarity, and stability.

Traceability confirms that the source of the requirement is known, e.g., a requirement may be traceable to customer needs and expectations, environmental or legal constraints, operational conditions, or to other requirements. Demonstrate forward and backward traceability between needs and requirements, i.e., all approved needs are met by one or more requirements, and all requirements meet or contribute to meeting at least one need. Assure that requirements are achievable by methods available to the project that will supply or develop required products/services. Assure that requirements are operationally feasible and can satisfy needs and expectations considering context, assumptions, and constraints of the intended environment. Assure feasibility in terms of affordability and risk. Assure that there is a way to determine that the requirement has been satisfied using methods of verification such as inspection, test, demonstration, and analysis.

Incomplete, ambiguous, or conflicting requirements are identified and resolved. Throughout the life cycle, requirements are analyzed when evaluating requirements changes.

Typical Work Products
- verifiability status of requirements
- requirements verification matrix
- requirements database connected with automated tools
- intended methods for verification of requirements
- requirements for verification plans
- results of feasibility, consistency, and completeness checks
- confirmation of traceability
- results of peer review of requirements documents
- assessment of risks related to requirements

Notes
This practice ensures that requirements are well-formulated. Some additional examples of criteria that may be established include writing requirements as single (not compound), positive (not negative) statements, that include tolerances (rather than absolute values) when applicable.

Requirements may be analyzed via peer reviews or other evaluation methods (see Evaluation (PA 08)). Depending on the method chosen for expressing the requirements, automated checks may be possible. The adequacy and completeness of requirements can be explored using prototypes, simulations, analyses, scenarios, and storyboards. Use of prototypes or simulations can help determine the cost associated with requirements and the risk that the resulting product or service will not perform appropriately in its intended use environment.

Confirm that derived requirements are necessary and sufficient to meet the objectives of higher requirements, that the requirements are a necessary and sufficient response to customer needs and expectations, and that they provide necessary and sufficient input to other processes, in particular Design (PA 03).

Identify and resolve requirements that have questionable utility, are outside project scope, or have unacceptable risk of not being satisfied. Use practices of the Needs process area (PA 01) to resolve ambiguous, incomplete, or conflicting requirements.

Additional Practice Guidance

- Analyze requirements to ensure that they are complete, correct, realizable and verifiable.
- Develop and document system and subsystem verification criteria concurrently with requirements development.
- Formally review or inspect requirements for quality attributes including stability, lack of ambiguity, and traceability to the customer baseline.
- Perform analyses, simulations, or prototypes to assure that system requirements will satisfy stakeholder needs and expectations.
- Allow for expansion and growth in system requirements.

BP 02.07 Record and baseline requirements

Record, approve, baseline, and place under change control, all requirements, derived requirements, derivation rationale, traceability, and requirements status.

Description
This base practice captures and records all requirements developed through the other Requirements base practices and assures that customers, suppliers, and key stakeholders agree that documented requirements satisfy needs and expectations and conform to agreed quality criteria. The captured, documented requirements, once approved, are baselined and form the basis for systematically developing and verifying a solution that meets the customer's operational and performance expectations within acceptable constraints of cost and schedule. Key requirements, priorities, decisions and assumptions are captured. Captured results also include other attributes of requirements such as a unique requirement number, interpretation, verification method, traceability, issues, and acceptance/change status. Acceptance criteria for requirements are also captured and controlled.

Typical Work Products
- requirements document
- concurrence from the customer and other stakeholders that documented requirements satisfy agreed-upon needs and expectations
- requirements baseline
- system specification
- specification
- A-level specification
- B-level specification
- requirements databases
- interface requirements document
- functional architecture
- contracting requirements

Notes
This practice assures that all requirements are written down, agreed upon by customers and suppliers, and then baselined. Requirements can be expressed in any way as appropriate to the customers and suppliers. Requirements may be grouped or partitioned according to established criteria or categories. Example views of requirements are functional, object, context, timeline, or user interface. Base practices BP 02.01 through BP 02.05 are examples of ways of grouping requirements.

Examples of ways to obtain customer agreement include formal reviews of requirements with customers and stakeholders, and demonstrations by means of simulations or prototypes. It may be necessary to negotiate with the customer and other stakeholders to assure the requirements represent an optimum balance of needs and expectations.

Examples of activities for capturing results and rationale include:

- Enter requirements, their traceability, and status into a requirements database.
- Distribute, review and coordinate requirements data with customers, stakeholders, and solution providers.

Configuration Management (PA 16) practices support capturing and baselining of requirements.

The capture of results and rationale applies to all the practices associated with the requirements, as well as to the analysis alternatives and design decisions.

Additional Practice Guidance

- Transform customer/user requirements into a set of system-level requirements.
- Define a system requirements baseline.
- Obtain an agreement between acquirer and developer that system-level requirements reflect their needs and expectations.
- Review adequacy of system requirements to meet stakeholder needs with key stakeholders.
- Negotiate an agreement between stakeholders and developers that system-level requirements represent an optimum balance of their needs and expectations.
- Perform analyses, simulations, or prototypes to assure that system requirements will satisfy stakeholder needs and expectations.
- Formally review requirements with stakeholders.
- Capture relationships between requirements for consideration during change management and requirements allocation.
- Maintain the status of requirements.
- Establish a derived requirements baseline, including the allocation of requirements to subsystems and system components.
- Capture rationale for system-level requirements, derived requirements, allocations, and traceability.
- Baseline (describe, capture, and control) and communicate requirements and functional architectures to all stakeholders.
- Partition requirements into groups, based on established criteria (such as similar functionality, performance, or coupling) to facilitate and focus the requirements analysis.

BP 02.08 Analyze and resolve requirements change requests

Analyze all requirements change requests for impact on the product or service and, upon approval, incorporate the approved changes into the requirements baseline.

Description

Requirements evolve throughout the life cycle. Establish a process for receiving, formally controlling, and managing changes to requirements considering impact prior to commitment to change, and gaining customer, stakeholder, and project concurrence. Proposed changes to baselined requirements are documented, along with their sources and rationale. They are analyzed to determine impact on the product or service, performance, architecture, supportability, effectiveness, suitability, resource utilization, benefits, schedule, and cost. Changes are analyzed for risk. Changes that will produce impact require negotiation for approval before they are incorporated into the requirements baseline (and subsequently into the product, work plans, and activities). Unapproved changes are documented and maintained for an audit trail. Changes are tracked to completion.

Typical Work Products

- revised requirements baseline
- requirements database
- configuration management plan
- change control notices, including version and other change history

Notes

By requiring formal analysis and concurrence on requirements change requests, and by tracking rationale, spurious change requests can be minimized. Configuration Management practices (PA 16) support maintaining and controlling the requirements baseline.

Additional Practice Guidance

- Document changes to requirements.
- Establish a process for formally and proactively controlling and managing changes to requirements, considering impact prior to commitment to change, gaining stakeholder buy-in, and tracking and closing out the actions and results.
- Evaluate the impact of requirement changes from the standpoint of all stakeholders.
- Periodically review requirements and their relationship with system functional and physical architectures.

BP 02.09 Maintain consistency and traceability

Maintain traceability among requirements and between requirements and plans, work products, and activities, initiating corrective action if inconsistencies are identified.

Description
Capture, maintain, and control the traceability and status of requirements throughout the life cycle. Of particular importance is the relationship between higher-level requirements and their associated derived requirements, which represent the higher level requirement. A continuous assessment of the lower-level requirements and their traceability and sufficiency is conducted to ensure that the developed system, product, or service meets all the requirements, but does not have features beyond those necessary to meet the requirements. That is, lower-level requirements are necessary and sufficient to meet the objectives of higher-level requirements. As requirements change, maintain traceability to customer needs and expectations as well as to plans, designs, verifications, validations, interfaces, work products, and activities. Similarly, assure that changes in work products and activities are traceable to requirements. Initiate corrective action if inconsistencies are found between the requirements and plans, work products, activities, and agreements.

Typical Work Products
- requirement exception report
- requirement traceability tables
- requirements tracking system
- requirements traceability matrix
- corrective action requirements
- inconsistencies, including sources, conditions, and rationale

Notes
Requirements form the basis for work plans and for the development and maintenance of the product or service throughout the life cycle. When proposed changes to these requirements are approved, the affected project plans, work products, activities, and agreements need to be adjusted to remain consistent with the updated approved requirements. Appropriate corrective actions are initiated, if required, to ensure that the requirements are used as the basis for plans, work products, and activities. Implementation of this base practice ensures consistent project processes that integrate project activities to produce correct, consistent products. The requirements, design, implementation, and verification methods are traced to the source from which they were derived and to the products of the subsequent engineering activities. Plans and products are kept consistent with the requirements.

Example activities include:
- Perform analyses to ensure that related sets of derived requirements, taken as a whole, meet the intent of the parent requirement.
- Perform analyses to ensure that there are no unnecessary requirements.
- Verify requirements traceability.

- Review plans, activities, and work products for consistency with requirements and changes made to them.
- Initiate corrective action if inconsistencies are found and changes need to be made to plans and work products.

All practices involving creating, changing, or verifying requirements (especially those of the process areas Needs (PA 01), Requirements (PA 02), Design (PA 03), and Evaluation (PA 08)) must maintain requirements traceability. Requirements form the basis for practices in the Project Management (PA 11) and Design Implementation (PA 06) process areas. Corrective actions identified are tracked to closure using Project Management (PA 11) practices.

Additional Practice Guidance

- Maintain requirements traceability to ensure that lower-level (derived) requirements are necessary and sufficient to meet the objectives of higher-level requirements, and are consistent with the product's functional architecture.

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PA 03: Design

Process Area Summary

Purpose
The purpose of the Design process area is to establish and maintain an architecture and design solution for the needs and requirements of the customer and other stakeholders.

Major points addressed
Examination of alternative approaches to solving the technical problem is crucial to achieving an effective solution that meets the requirements. The requirements (resulting from PA 02 processes) for products and services are an input to this process area and include performance, functionality, effectiveness, and interfaces to the environment. The environment may include other, or larger, systems of products and services. The architecture and design elements of the selected solution structure are specified in terms of their allocated product and service requirements (including external constraints), the solution-dependent constraints and requirements, and their internal interfaces. A technical information package that documents all aspects of the design, including key technical features that guide the evolution of the product and services, is established, baselined, and maintained.

Goals
1. A product or service design that meets the product and service requirements is established and maintained. *(BP 03.01, BP 03. 02, BP 03.04, BP 03.05, BP 03.06, BP 03.07, BP 03.08)*
2. The established product or service design is based on an evaluation of alternatives against criteria that represent the requirements. *(BP 03.02)*
3. Allocations of requirements to the design elements are established and maintained. *(BP 03.04)*

Notes
The practices of this process area apply to products, services, and combinations thereof. In the case of tangible products, the purpose and practices correspond to architecture and design. Designs for service applications include similar work products. Service design descriptions include service elements (e.g., ground traffic control component, air traffic control component) and interfaces (e.g., procedures for communication between air traffic control and ground traffic control). For a general service unit, its service design descriptions may specify the different service elements (e.g., customer assistance, request processing) and their interactions.

The requirements pertaining to a design (including external interfaces relating to the environment and larger system of which the target product or service is a part) are established by the practices of PA 02, Requirements. Design activities are applicable to all subsequent cycle phases of a product or service and may be initiated either by new development, changes in requirements, or corrective actions. The practices of this process area should be applied at each level of product or service decomposition and definition. In the case of product architecture and design, the practices are applied to definition of

the first layer of elements that integrate to form the product, as well as to definition of succeeding layers. The level of detail and rigor of application of the practices are adjusted as appropriate to the level of decomposition. For example, an interface specification would typically need to be more detailed and complete for a component-to-component interface than for a subsystem-to-subsystem interface.

The same principles apply for successive application of the process area practices to define layers of service design. Designs are developed for successively lower layers of the architecture until the elements for implementation (PA 06 Design Implementation) or outsourcing (PA 05 Outsourcing) are specified.

The term "element" is used to denote a generic part, component, or piece of a service or solution. Elements of products include subsystems, assemblies, components, parts, etc. Elements of service solutions include personnel, service procedures, and service tools and equipment.

Relationships between this PA and other PAs

Primary inputs to this process area come from the Requirements process area (PA 02). The Requirements process area establishes the required functions of the product or service (including external interfaces to the environment and other products/services of a larger system) and how well (in quantitatively measurable terms) the product or service is expected to perform the functions.

Early stages of design typically include iteration with the Needs (PA 01) and Requirements practices to establish technical, cost, and schedule feasibility and constraint parameters. Operation and Support (PA 10) activities may generate design change requests that flow through Requirements (PA 02) for analysis and change approval. Activities are planned and controlled via the practices of Project Management (PA 11). Integrated Teaming (PA 14) practices provide effective collaborative approaches for product and service design activities. As the design evolves, consistency is maintained with the work breakdown structure to assure cost and work accountability is maintained.

The process area generates alternative design solutions and makes use of the Alternatives Analysis process area (PA 04) to seek additional alternatives that meet established criteria for the product or service, and prioritize and/or recommend preferred alternatives. Critical technical issues are considered in Risk Management (PA 13).

Work products of the process area are evaluated according to practices of Evaluation (PA 08) and Quality Assurance and Management (PA 15). Product or service elements defined in PA 03 are implemented by practices of the Design Implementation (PA 06) process area or acquired through the practices of Outsourcing (PA 05). The Integration process area (PA 07) integrates the implemented elements.

Baselines for the work products are established and maintained by the Configuration Management (PA 16) process area practices. Design may add features (e.g., specific materials) that affect Deployment, Transition, and Disposal (PA 09). Formal and informal design information, whether placed under configuration management or not, is

preserved for reference by the practices of Information Management (PA 17). Architectural features and structures that support evolution of the product or service are coordinated via the practices of the Innovation (PA 23) process area.

Base practices list

BP 03.01 **Identify and prioritize design issues**: Establish and use a mechanism to capture, prioritize, and resolve product and service design issues.

BP 03.02 **Develop design structure**: Evaluate alternatives against established criteria to select the architecture, structure, and elements for the product or service design.

BP 03.03 **Develop interface specifications**: Develop interface specifications for the selected product and service elements.

BP 03.04 **Allocate requirements**: Allocate product and derived requirements to the design elements and interfaces, and to personnel or processes where appropriate.

BP 03.05 **Define interactions among design elements:** Define the dynamic interactions and operational sequences among design elements.

BP 03.06 **Establish component specifications:** Establish design specifications for each element of the product or service.

BP 03.07 **Establish and use a strategy for non-developmental Items:** Establish and use a strategy for managing issues relating to the use of non-developmental item (NDI) product and service elements.

BP 03.08 **Establish and maintain design description:** Establish and maintain a complete description of the product and service design.

BP 03.01 Identify and prioritize design issues

Establish and use a mechanism to capture, prioritize and resolve product and service design issues.

Description
An effective design synthesis activity includes established and maintained processes to manage the many issues that arise during development of the design. Staff should be encouraged to identify and document design issues. An evaluation must take place to prioritize issues, identify risks, and determine the subset of the many issues that are the drivers for the product or service. (Drivers and key issues are those that meet project-defined thresholds for effect or potential effect on cost, schedule, and technical objectives.) The subset of key technical design issues becomes a constraint on the product or service design and development. This activity also identifies analyses and trade studies that are performed to resolve issues and select appropriate design alternatives. Key technical issues are input to or output from Risk Management (PA 13).

Typical Work Products
- decisions and rationale
- documented methods and procedures for identifying and managing technical issues
- action item and status list of architecture and design issues
- risks
- list of architecture and design issues, with those that are key identified
- list of service issues, with those that are key identified
- analyses to be performed
- trade studies to be performed

Notes
Unless established procedures are used to collect and manage product architecture and design issues to closure, delays in issue resolution may result in increased cost and schedule risk. Similar considerations apply to management of service solution issues. Key solution issues may include cost drivers, performance drivers, risk, or technology. In an integrated product/service team environment, key design issues may identify the need for "specialty engineers" to be a part of the design team. There may be issues seemingly unrelated to the product that become key design issues. An example of such an issue is compliance with laws governing the manufacturing or disposal of a product.

An example of a mechanism to manage solution issues would be a procedure/process that results in a weekly project status meeting agenda item to solicit, status, and assign actions on issues. A typical issue relating to product synthesis might be “ The vendor documentation on the data base manager contains discrepancies in the details of the application interface.” A typical issue relating to a service synthesis might be “ The selected training for the customer service element seems to conflict with personal privacy law.”

Additional Practice Guidance

- Capture the rationale for key (i.e., significant effect on cost, schedule, or technical performance) decisions taken or deferred.

BP 03.02 Develop design structure

Evaluate alternatives against established criteria to select the architecture, structure, and elements for the product or service design.

Description
Alternative designs (architecture, approaches, and structure) and evaluation criteria are defined and the Alternatives Analysis process (PA 04) is used to refine the problem statement and prioritize or recommend alternatives. Evaluation criteria should be based on the product and service requirements and include factors relating to cost, schedule, and performance. This element of the design process considers the results of the alternatives analysis and selects the design structure.

Alternatives analysis is applied to define the design for each level of design definition (design layer). The first level of design decomposition defines the architecture and the lowest level of design establishes the design specifications for the construction or acquisition of product or service elements. Evaluation and selection criteria are based on key requirements and constraints. Features of alternative designs are considered which provide a foundation for product and service improvement and evolution. The rationale for the selected design, and for designs not accepted, is documented and maintained for future reference as the product or service evolves.

Typical Work Products
- design alternatives
- evaluation criteria
- trade study or analysis results
- documented rationale for selection and non-selection(s)
- architecture structure and elements
- identified interfaces
- engineering drawings
- service approach and service elements

Notes
The identified elements of the product's architectural structure constitute the major "pieces" of the product to be developed, upgraded, maintained, or integrated. For new development, these elements are best selected through the analysis of alternatives against established requirements or criteria. In the case of reuse or upgrades of existing systems, use of an existing architectural structure or its elements may be a requirement.

Design selection criteria include many factors. Items to consider in establishing selection criteria and selecting a preferred design include:
- Product or service life cycle cost (initial cost, operations, maintenance, disposal)
- Technical performance
- Product or service complexity (especially user interface)
- Robustness to product operating and use conditions (e.g., graceful performance degradation resulting from input overloading, adverse environment, or component failure)

- Product performance reserves, expansion and growth
- Technology limitations
- Sensitivity to construction methods and materials
- Risk
- Safety
- Evolution of requirements and technology
- Disposal

In the architecture and design of new or unprecedented products, there are many opportunities to consider alternatives. Such opportunities diminish with existing of precedented products and systems. It is generally desirable to establish criteria for which design decisions should be subjected to alternatives analysis or trade study. Not all design decisions warrant a formal analysis.

Analysis of alternatives should be considered for each design layer and for elements within layers. ("Layers" are sometimes called "levels of design decomposition", e.g., system, sub-system, assembly, component.) Alternatives should be solicited from a broad range of stakeholders. A common pitfall in product design is to accept a favorite or unfounded design (sometimes called a "point design) and perform a trade study after the fact to justify the selection.

An example of a product architectural decision that considers product evolution is the choice of a commercial off-the-shelf (COTS) data base manager whose application interface is expected to be stable over several generations of product improvement. Reuse of COTS and non-developmental item (NDI) elements should be considered relative to life-cycle cost (initial cost, performance and product maintenance).

Examples of alternatives analysis for a service include alternatives for organization of the service capabilities, geographical location of service capabilities, and service capabilities to be outsourced.

Additional Practice Guidance

- Compare new designs with a similar proven designs.
- Consider current and emerging technologies.
- Allocate key requirements to alternative solutions to aid in their evaluation.
- Develop operational and maintenance scenarios for alternative solutions.

BP 03.03 Develop interface specifications

Develop interface specifications for the selected product and service elements.

Description
Specifications containing a well-defined set of requirements are established for interfaces among product and service elements. External interface details not specified in the top-level product and service requirements are completed. Format and content for interface specifications should be based on industry standards or on internally established and maintained standards.

Typical Work Products
- interface specifications
- interface scope sheet
- interface requirements
- user interface specifications
- environmental interface specifications
- subsystem interface specifications
- component interface specifications
- service element interface specifications

Notes
An interface specification is a document or other collection of information that fully describes an interface in terms of all the constraints and design requirements placed on the interface. Interfaces should be well-defined according to established standards for information content. For example, well-defined product element interfaces may include message origin, destination, communications event stimulus, data element characteristics (range, data type, precision, accuracy, etc.), and electrical and mechanical properties. External interfaces are usually established prior to development of the product or service design, as part of the requirements. This occurs either by invoking the interface constraints of an existing system (PA 02) or through a higher-level application of the design process area to a product or service in a different scope or context. Maintenance and coordination of interfaces is described in the Integration process area (PA 04). Functional interface requirements are addressed in the Requirements (PA 02) process area.

It is usually advantageous to employ standards (national, international, industry, organizational) for interfaces. ISO and IEEE are common sources of interface standards for computer applications.

Additional Practice Guidance
- Establish and maintain standards for the format and content of interface specifications.

BP 03.04 Allocate requirements

Allocate product and derived requirements to the design elements and interfaces, and to personnel or processes where appropriate.

Description
Requirements allocation involves the unambiguous assignment of the product requirements to design elements, or to staff, processes, and enabling elements. Requirement allocations are dependent on the selected product architecture and design and often require that the performance attributes of higher level requirements be partitioned among product elements. Performance of the architecture and design is analyzed, and iterated and the product architecture and design requirement allocations refined and modified as necessary.

Typical Work Products
- function and performance allocated to architecture and design components
- derived requirements needed to partition performance among components
- function and performance allocated to personnel
- documentation of requirement allocations to personnel and components
- requirements allocation traceability data

Notes
Initially requirements may be assigned to elements without resolution of shared or redundant functionality or performance. When the performance or functionality of a requirement spans multiple subsystems or elements, analysis is performed to determine an allocation of the requirement's function or performance appropriate to each element. Derived requirements are then formulated to specify the performance allocation or partition appropriate to each element. As existing, new, or derived requirements are allocated to architecture elements, they are verified for correctness and completeness against established criteria and in the context of operational sequence (BP 03.05) threads. As requirements are analyzed and allocated, appropriate requirements are added to address all phases of the product's life cycle (e.g., production, support, and disposal) along with any design constraints associated with selected solution elements.

As an example, a requirement that the system respond to a specific user action within 1 second may need to be partitioned and allocated to user interface, communications, and data base subsystems. The result of allocation might be new derived/allocated requirements that the user interface subsystem process the user input within 0.3 seconds, the communications infrastructure process the request and response within 0.2 seconds, and the data base respond (on average, with specified loading) within 0.5 seconds. A different architecture, say a subsystem in which the user interface and data base are an integrated COTS product, would typically result in different derived and allocated requirements.

"Enabling" elements include user and maintenance documentation, operating processes/procedures, and product operating and maintenance training.

Additional Practice Guidance

- Review derived and allocated requirements for completeness and correctness against established criteria and in the context of operational sequence threads or scenarios.

BP 03.05 Define interactions among design elements

Define the dynamic interactions and operational sequences among design elements.

Description
Operational concepts and sequences created in the determination of needs and requirements are refined and decomposed to capture the dynamic interactions and reactions of the selected product and service elements to stimulation from the user, the environment, and other elements. The detailed element interaction sequences are used to achieve an improved understanding and description of candidate and selected solutions by reviewing the components and their aggregate behavior in the context of event by event reviews of operational sequences. In the case of services, the dynamic interaction among service capabilities would be defined. The interaction sequences are also used to confirm the accuracy of interface specifications and as the basis for test and evaluation cases (test scripts).

Typical Work Products
- component interaction sequence diagrams/descriptions
- component interaction timing constraints
- service capability interaction scenarios and sequences
- event trace diagrams at subsystem and component level
- dynamic views of product component behavior
- product support scenarios
- maintenance scenarios

Notes
For hardware and software products, operational scenarios and sequences capture the dynamic characteristics of the interaction among product elements. (Interface specifications capture only static relationships.) This includes the stimulus-response time sequenced behavior of each product element to events and transitions between various product states and modes. Experience has shown that reviewing the design element requirements in the context of such operational sequences is an invaluable aid to achieving accuracy and completeness in their requirements. Product operational scenarios and sequences, at appropriate sub-product levels, should be documented for operations, product deployment/delivery, support (including maintenance and sustainment), training, and disposal for all modes and states. The environment experienced by any given product element will be influenced by other product elements, as well as the external environment. Examples of environmental influences include thermal, stress, air quality, or electromagnetic factors.

Similar scenarios and sequences should be described for dynamic interactions among service capabilities. An example would be the operational sequence and procedures for the hand-off of air traffic control from one area of airspace control to another. Definition and review of product and service operational sequences, at multiple levels of the design, are essential for synthesis of the solution, a complete and common stakeholder understanding of the solution, and to assure the determination of a complete and accurate set of design-specific element requirements.

Relationship of this practice to the practices in the Needs (PA 01) process area: Operation sequences described in the Needs process area document the interaction of the product or service with the user and the environment. This operational sequence description does not address how the product elements (because they are generally not known in this phase) contribute to the product response to external stimuli. This practice expands the operational scenarios described in the Needs process area to include the dynamic behavior of the product elements.

Documentation of the dynamic interaction of product elements is appropriate at each level of product and service decomposition.

Additional Practice Guidance

- Expand use cases to include subsystem and component reactions.
- Develop subsystem and component event trace or object interaction diagrams to support each use case.
- Identify events that cause state or mode transitions.
- Document product and component trouble-shooting and repair scenarios.
- Identify operational events that pose safety or health risks.
- Establish component-level operational scenarios for training modes.
- Evolve the operational concept, scenarios, and sequences to a level of detail appropriate to each level of solution decomposition.
- Develop element-level timeline scenarios for system operation and user interaction for each alternative product or system design.

BP 03.06 Establish component specifications

Establish design specifications for each element of the product or service.

Description
A complete set of detailed design specifications for each element includes all the design constraints, interface constraints, and allocated requirements that are necessary and sufficient in order to produce or acquire an element that is capable of meeting its verification and validation conditions. At intermediate levels of design, the design specifications of an element are used either as the basis for design of that element or for outsourcing that element. At the lowest layer of design, the element (component) design specifications provide the essential conditions for construction or coding of the element. The possible categories of element design constraints and requirements are broad and varied, typically including constraints imposed by selection of another design element, the need to conform to another design element's interface, and allocated design-level functional, performance, and interface requirements.

Typical Work Products
- subsystem constraints and design requirements
- service element specifications
- component specifications
- component documents and specifications
- design constraints

Notes
A design specification fully describes a product element and its interface in terms of all the constraints and design requirements (including functional, allocated, performance, and constraints) placed on the element or interface and the qualification method for each requirement. Product element specifications are expressed in solution/how (implementation) terms, rather than problem/what (domain or external world) terms.

Standards and templates are useful for determining the format and content of product element specifications. In defining the architectural structure, the selection of a one element often results in new interface requirements on other elements. Such requirements, sometimes called design constraints, constitute new solution-imposed requirements that result from the design activities and must be included in the element specifications. New element requirements are also introduced during the design process as a result of partitioning the performance of product requirements for allocation to selected elements.

The specification of an element in one layer of a design constitutes the input requirements for application of the design process to determine the solution (structure, elements, interfaces) at a lower level.

Additional Practice Guidance

- Identify design constraints as requirements for each level of design.
- Specify development elements with the same level of rigor as procured elements.
- Review component requirements to assure that the components are necessary and sufficiently specified with respect to the satisfaction of higher level-requirements.

BP 03.07 Establish and use a strategy for non-developmental items

Establish and use a strategy for managing issues relating to the use of non-developmental item (NDI) product and service elements.

Description
The selection and management of NDI (re-useable components, commercial off-the-shelf components, customer or other stakeholder components) poses a specific class of product and service issues. In many cases, analyses or trade studies should be performed on the choice of developing an item or using an NDI. Factors that should be considered with NDI include the capability to meet requirements, the completeness and accuracy of NDI documentation (especially for interfaces), the existence of unneeded functionality, interoperability of evolving versions and updates, availability of spares, and the continued availability of maintenance. Internal reuse requires that elements be designed according to standards that enable reuse.

Typical Work Products
- criteria for evaluating and selecting commercial off-the-shelf products
- standards for designing for reuse
- standardized suites of commercial off-the-shelf products
- make-buy analyses and trade studies
- strategy for NDI

Notes
Refer to the Alternatives Analysis (PA 04) process area for practices that address defining criteria, alternatives and performing structured analysis and decision making. Make, buy, and reuse decisions significantly impact both project and organization success; in general the choice to develop or use NDI is not clear until analyses are performed. 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. Once the decision is made to purchase an off-the-shelf product the appropriate solution element specifications are used to establish a supplier agreement. Outsourcing (PA 05) also addresses some of these issues, but this practice more broadly includes the strategy surrounding the use of NDI in solution development.

Often available NDI components do not provide the exact product element features that are required. Candidate components may have modest shortcomings, cost more or less, and/or have desirable features that are not required. When this is the case, it may be desirable to discuss or negotiate with the customer/user for requirement changes. Such changes may or may not be advantageous to the customer/user.

Additional Practice Guidance

- Plan for the maintenance of selected commercial off-the-shelf products.
- Plan for the evolution of commercial off-the-shelf product versions and potential impacts on the product or service under development.

BP 03.08 Establish and maintain design description

Establish and maintain a complete description of the product and service design.

Description
The design description provides the information needed to implement (build, code, construct, etc.), operate, and maintain products and the information needed to establish and maintain policies and procedures for service elements. The completeness and clarity of the design description contribute to efficient and accurate implementation, the success of verification and validation, and the improvement and evolution of the products and services. A complete design description will include reference to the input requirements, alternatives considered, rationale of solution selections and decisions, structure, element specifications, interface specifications, requirement allocations, data definitions, dynamic behavior, and descriptions of enabling products and services.

Typical Work Products
- technical data package
- physical architecture
- subsystem specifications
- component specifications
- interface specifications
- requirement allocations
- interface control documents and drawings
- data flow diagrams, object interaction diagrams, event trace diagrams
- design documents
- requirements traceability table
- description of service departments
- service policy and procedure requirements (for selected service organizational structure)

Notes
A design description is sometimes called a technical data package.

Typically, a complete set of design information can be very large and complex. A well thought out and organized approach to managing the information is recommended, and industry or internal standards should be used for the format and content of solution descriptions. Industry-wide approaches and standards are emerging that organize the solution information (architecture and design description) into “views” (sometimes called design views). Typical views include operational view, system view, and technical architecture view. Stakeholder access to solution description should be convenient and include any appropriate privacy or security controls.

Determining the number of levels of product elements (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 planning.

Additional Practice Guidance

- Verify that the described design, if implemented, would meet product and service requirements, through analysis, prototyping, modeling, or simulation.
- Establish and maintain a repository for design data that provides efficient retrieval and protection.

PA 04: Alternatives Analysis

Process Area Summary

Purpose
The purpose of Alternatives Analysis is to apply structured analysis and decision-making to selected issues and communicate the results to stakeholders.

Major points addressed
Alternatives analysis supports structured decision making and involves identifying appropriate issues that require a structured analysis and decision process, involving stakeholders, selecting a analysis methods, identifying alternatives and selection criteria, applying the analysis methods, and storing and communicating the results. Established guidelines are needed to identify those issues for which structured analysis is appropriate. Storing analysis results and rationale provides a basis for future analyses and a reference when the same or similar issues resurface. Structured analysis and decision-making processes reduce the subjective nature of the decisions and are more likely to result in solutions that meet stakeholder needs.

Goals
1. Strategies are established and maintained that support the analysis of alternatives and structured decision-making. *(BP 04.01)*
2. Alternative solutions to selected issues are analyzed and solutions selected or recommended in accordance with established strategy and criteria. *(BP 04.02, BP 04.03, BP 04.04, BP 04.05, BP 04.06)*
3. Results and rationale of alternatives analysis are documented and communicated. *(BP 04.07)*

Notes
Alternatives analysis guidelines are used to identify those issues that are appropriate for informal analyses, by an individual or group, and issues that should be subjected to alternatives analysis. In many cases alternatives analysis and decision-making are tightly integrated as a process; however, in some cases alternatives analysis is employed as a sub-process to provide a recommended solution or ranked list of solutions to a separate decision-making process or entity. Structured alternatives analysis processes vary in formality, type of criteria, and method. Less formal alternatives analyses 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 alternatives analyses may require separate plans, months of person-hours, meetings to develop and approve criteria and goals, simulations, prototypes, piloting, and extensive documentation. There may be a reluctance to use structured techniques when the criteria are not conducive to objective analysis. Parameters of various alternatives are not always quantifiable. Where structured techniques or other analysis methods may not be straight forward, the analysis can be supplemented with expert judgment.

Typical issues that may require structured alternatives analysis include: key features to be included in products or services, mission/business goals, technology and architecture selection, trade-offs between project size and schedule, development life cycle, make-or-buy, supplier selection, integration strategy, customer service approach, maintenance strategy, and risk mitigation approaches.

Relationships between this PA and other PAs

Structured alternatives analysis methods may be invoked by processes relating to every process area. Examples of issues that may require structured alternatives analysis are presented in the following table, organized by Process Area.

Process Area	*Example Analysis/Decision Issues*
PA 00 Integrated Enterprise Management	Selection of specific mission or business opportunities
PA 01 Needs	Resolving conflicting needs and expectations
PA 02 Requirements	Determining key requirements
PA 03 Design	Selection of architectural elements, design structure, technology, make-or-buy analysis
PA 05 Outsourcing	Supplier selection
PA 06 Design Implementation	Selection of implementation methods/tools
PA 07 Integration	Integration sequence; selection of integration strategy
PA 08 Evaluation	Verification methods
PA 09 Deployment, Transition and Disposal	Transition strategies
PA 10 Operation and Support	Support strategy
PA 11 Project Management	Development life cycle (e.g., waterfall, spiral)
PA 12 Supplier Agreement Management	Methods of monitoring supplier performance
PA 13 Risk Management	Risk mitigation method
PA 14 Integrated Teaming	Resolution of team issues
PA 15 Quality Assurance and Management	Selection of quality assurance tools; defect elimination methods
PA 16 Configuration Management	Selection of method for processing change request
PA 17 Information Management	Selection of information storage system
PA 18 Measurement and Analysis	Selection of measures
PA 20 Process Definition	Process goals
PA 21 Process Improvement	Process improvement goals
PA 22 Training	Selection of training courses to be offered; selection of how skills are to be provided
PA 23 Innovation	Technologies to pursue or insert

Base practices list

BP 04.01 **Establish analysis strategy:** Establish and maintain an alternatives analysis strategy that provides guidelines for when and how to use structured analysis and decision methods.

BP 04.02 **Define the problem:** Define the problem and establish criteria and their relative importance for evaluating alternative solutions.

BP 04.03 **Select analysis method:** Select alternatives analysis methods and document the rationale for their choice.

BP 04.04 **Identify alternative solutions:** Identify and document alternative solutions to problems or issues.

BP 04.05 **Analyze alternative solutions:** Analyze alternative solutions in accordance with the selected alternatives analysis method and evaluation criteria.

BP 04.06 **Select solution:** Select or recommend solution(s) that best meet the criteria and goals of the analysis.

BP 04.07 **Communicate analysis results:** Document and communicate alternatives analysis results to stakeholders.

BP 04.01 Establish analysis strategy

Establish and maintain an alternatives analysis strategy that provides guidelines for when and how to use structured analysis and decision methods.

Description
An alternatives analysis strategy includes guidelines for identifying issues that should be subjected to structured analysis and decision-making methods, approval authority for specified types of issues or decisions, approved methods for making structured decisions, requirements for issue resolution and coordination, and requirements for communication and documentation of analysis, decision rationale, and results.

Many problems and issues do not require structured analysis; others are somewhere between the trivial and the clearly important. Guidelines are needed to determine which issues should be resolved through structured analysis methods.

Typical Work Products
- guidelines for when to apply structured analysis and decision-making
- approved methods for alternatives analysis and decision making
- list of decision approval authorities by decision type

Notes
Typical guidelines for determining when to require structured analysis and decision-making include the following:
- an issue is directly related to topics assessed as being of medium or high risk
- an issue or decision is related to changing work products under configuration management
- an issue or decision could cause schedule or cost delays exceeding a specific amount of time or cost (e.g., place >5 percent of project budget at risk)
- an issue affects the ability to achieve project objectives
- design implementation issues in which technical performance failure may cause a catastrophic failure (e.g., safety of flight item)
- safety issues
- issues with the potential to significantly reduce design risk, engineering changes, cycle time, and production costs
- the costs of the analysis and decision-making process are reasonable, compared to the decision's impact

Decision authority procedures may base approval on the cost and/or risk and require approval by one or more persons at appropriate levels of responsibility. Requirements for issue resolution coordination should involve appropriate stakeholders, disciplines, or functional areas.

BP 04.02 Define the problem.

Define the problem and establish criteria and their relative importance for evaluating alternative solutions.

Description
Define or confirm (if the problem statement is received from another process) the problem description and solution criteria. The problem or issue should be clearly described for understanding by stakeholders, analysts, and decision-makers. Criteria that indicate the expected or required characteristics of a selected solution and that will be used to judge the relative merit of alternatives are established and documented. The weights or relative value of evaluation criteria are established for use in comparing alternatives

Typical Work Products
- detailed problem definition
- goals, criteria, ground rules for decision-making
- rankings or weighting of criteria according to importance
- scoring functions for selection criteria

Notes
The initial statement of a problem or issue may be incomplete, lacking in clarity, or involve inaccurate constraints. Better solutions and improved stakeholder buy-in can be achieved through a well-defined and mutually understood problem statement and by challenging constraints on solutions and requirements. Analyses and decisions, based on criteria and goals that are explicitly defined and documented, remove barriers to stakeholder buy-in. Evaluation criteria should be traceable to requirements, scenarios, business case assumptions, business objectives, or other documented sources. Depending on the analysis method, scoring functions (sometimes called utility functions) may be needed for each evaluation criteria. (For example, a scoring function for the "effort required" evaluation criteria in a trade-off analysis might award 10 points to candidate solutions that require an effort of less than 1000 hours and 5 points for solutions that require an effort of less than 1500 hours.) Documentation of the problem or issue and the evaluation criteria are important for future reference in case the issue needs to be revisited or referred to for additional analyses.

Untested criteria and goals, their relative importance, and supporting data or functions may cause the validity of solutions to be questioned. Criteria, goals and their relative priorities and scales can be tested with trial runs against a set of alternatives. Such testing allows the cumulative impact of a set of criteria and goals on the solution to be analyzed. In such cases, the alternatives may be different from the proposed alternatives to avoid biases.

Both numeric and non-numeric criteria and goals 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).

Additional Practice Guidance

- Evaluate the reasonableness and validity of assumptions, constraints, and requirements relating to the problem statement.
- Establish a standard set of evaluation criteria, appropriate to the organizational mission, such as technology limitations, environmental impact, risk, and life-cycle cost.
- Document the rationale for selection and rejection of evaluation criteria.
- Involve stakeholders in the selection and weighting of evaluation criteria.

BP 04.03 Select analysis method

Select an alternatives analysis method and document the rationale for the choice.

Description
Analysis methods are based on strategies and methods established and supported by the project or organization, and on consideration of the resources available and appropriate to the issue to be decided. Considerations in selecting an analysis method include acceptability to stakeholders, availability of expertise, availability of tools, method knowledge or training, method cost and schedule parameters, and the relative knowledge or lack of knowledge about the problem or issue.

Typical Work Products
- Selected analysis and decision making methods, such as:
  - trade-off study (e.g., Kepner-Tragoe)
  - Delphi Method
  - Analytical Hierarchy Process (AHP)
  - selection by an authorized individual
  - team consensus
  - team voting

Notes
The Kepner-Tragoe method (named for the authors of numerous publications on the method, and often referred to as a trade study or trade-off) is a widely used method that presents alternative solutions on one axis of a table (or matrix) and evaluation criteria on the other axis. Alternative solutions receive scores for each criterion, which may be increased or decreased by weights assigned to the criteria to prioritize their importance. The Delphi method utilizes inputs (judgment) from recognized experts to select a solution or decide an issue.

The Analytical Hierarchy Process (AHP) is well suited to making complex decisions involving multiple criteria. The analysis goal is decomposed into its constituent parts, progressing from the general to the specific. Alternatives are then further divided into an appropriate level of detail and relative weights assigned. Scoring is on a relative basis comparing one choice to another. Relative scores for each choice are computed within each leaf of the alternatives hierarchy.

Although some methods may appear to be highly objective due to the use of numeric values for scoring alternatives and weighting criteria, all methods employ some level of subjectivity. The value of using a defined method is that subjectivity may be decreased and localized (factual information separated from judgmental information) and the various aspects of an issue better understood by stakeholders. Stakeholder acceptance is increased by the use of a method that is well defined with documented results.

The selection criteria and the analysis method are interrelated. For example a criterion that depends on a simulation to provide analysis data may indicate a relatively expensive trade-off analysis. Use of expert judgment methods may require fewer resources but are dependent on stakeholder buy-in and may be less accurate than a detailed trade-off analysis.

BP 04.04 Identify alternative solutions

Identify and document alternative solutions to problems or issues.

Description
Seek alternatives in addition to those that may be provided with the problem statement. Alternatives are solicited from stakeholders, documented, and considered as possible solutions. Deliberate mechanisms (such as brainstorming sessions and interviews) are employed to obtain a broad-based set of alternatives. Alternatives are not challenged during the collection process, in order avoid stifling creativity of solutions. Subsequent to the alternatives collection phase, alternatives may be screened using objective criteria in order to provide a manageable set of alternatives to the analysis phase. New alternatives are considered, as they arise, throughout the decision process. The generation and consideration of multiple alternative solutions 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.

Typical Work Products
- identified alternative solutions

Notes
A wider range of alternatives can be obtained 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. Combining key attributes of existing alternatives can generate additional and sometimes stronger alternatives. Careful examination of the problem, criteria, and goals is an effective starting point for identifying additional alternative solutions.

Additional Practice Guidance
- Involve stakeholders in the selection and review of alternatives.

BP 04.05 Analyze alternative solutions

Analyze alternative solutions in accordance with the selected alternatives analysis method and evaluation criteria.

Description
Alternatives are analyzed according to the selected method. The score and/or other characteristics of each alternative are determined, reviewed and documented. The results indicate the relative value of each alternative with respect to the evaluation criteria and solution goals. Iterations of the evaluations are conducted as needed by review feedback or by the introduction of new alternatives and/or revised selection criteria. Trial results of the analyses are obtained and sensitivity analysis conducted to see if relatively small changes in evaluation criteria, scoring functions, or weights would change the outcome.

Typical Work Products
- scores, characteristics or comparisons of alternatives against selection criteria
- adjustments to selection criteria, scoring functions, or weights
- new alternatives
- documented analysis results

Notes
Analyzing alternative solutions involves analysis, discussion, and review. Iterative cycles of analysis are sometimes necessary. Supporting analyses, experimentation, prototyping or simulation may be needed to substantiate scoring and conclusions. 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.

Analysis parameters (e.g., selection criteria, their weights, and scoring functions) may need to be adjusted during the course of the analysis, as the problem becomes better understood. Such changes may be challenged as changing the criteria to achieve a desired (biased) solution. However, the initial analysis parameters may be imprecise and lack validation. Trial runs of the process to select a solution are often useful to test or validate the analysis parameters. Often such trial runs are made with “dummy” alternatives. Testing or validation of the analysis parameters should be a planned element of the analysis process.

Additional Practice Guidance
- Perform a sensitivity analysis to validate the evaluation criteria, their weights, and scoring functions.

BP 04.06 Select solution

Select or recommend solution(s) that meet the criteria and goals of the analysis.

Description
One or more solutions are selected or recommended in rank order based on the analysis of alternatives. The analysis and the selected solution or ranked list of solutions is reviewed to assure that the chosen analysis method was followed and that the criteria are valid for the recommended solution(s). When the analysis indicates that two or more candidate solutions are relatively close in meeting the criteria and goals, further analysis, expert opinion, and/or stakeholder input may be needed. Selection of the solution(s) should consider both short- and long-term implications of the solution(s), risks, and decision trees (indicating what other decisions may need to be made as a result of selecting a given solution).

Typical Work Products
- selected solution(s)
- list of solutions in rank order of goal/criteria satisfaction
- requests for additional analyses
- reviews

Notes
There can be substantial risk associated with any decision as a result of having incomplete information. When decisions must be made according to a specific schedule, time and resources may not be available for gathering complete information. Consequently, risky decisions made with incomplete information may require re-analysis at a later time. Identified risks should be referred to the risk management process and monitored.

The following questions should be considered in selecting a solution:
- How much better is the selected approach than the next best alternative?
- Is there a significant difference between the results of the comparative evaluation?
- Have all feasible alternatives been considered?
- What are the areas of risk and uncertainty?

Additional Practice Guidance
- Involve stakeholders in the selection and review of the solution(s).
- Review the analysis and the selected solution to confirm that the selection criteria were appropriately weighted (balanced) in selecting the solution.

BP 04.07 Communicate analysis results

Document and communicate alternatives analysis results to stakeholders.

Description
Communication of the recommended alternative or decision allows others to perform their assigned tasks or take action based on the decision. Additionally, communicating the basis for the decision enables stakeholders to understand why a decision was made and is especially important if the trade-offs in the decision appear to be unfavorable from other points of view. The documentation is distributed to the stakeholders and provides a record of the decision and rationale that is useful to other projects that encounter a similar issue. Documentation of analyses, decisions, and issue resolutions are often useful when the same or related issues arise in the future.

Typical Work Products
- documented analysis of alternative solutions
- mathematical models of appropriate solutions
- documented results of analyses
- other supporting data of all studies and analyses
- decision results
- rationale and description for preferred solutions
- rationale and description of rejected solutions
- criteria and goal selection and application to each alternative solution

Notes
Documentation of the analysis should include the method and rationale for its use, the selection criteria, weights and scoring functions, alternatives, ranking of alternatives, unresolved issues and dissenting views on the selection, and risks relating to the selected solution that need to be mitigated and/or monitored.

Examples of ways to capture results include:
- formal, deliverable documentation
- informal, internal documentation
- computer files
- a prototyped product
- an engineering log book
- change request database

PA 05: Outsourcing

Process Area Summary

Purpose
The purpose of the Outsourcing process area is to identify the portions of the solution and support structure that are to be provided from outside the organization, identify potential sources, and select the supplier for the needed capability.

Major Points Addressed
The Outsourcing process area involves identifying products or services to be provided by outside organizations, preparing and issuing the solicitation or tasking package, evaluating responses, conducting negotiations, and selecting the supplier.

Affected organizations and stakeholders must have a shared vision of the working relationship and roles in addition to coordination of schedules, processes, and deliveries of work products. This shared vision includes roles both during the selection process as well as after selection. Relationships can range from integrated developer and supplier product teams, to prime contractor and subcontractor, to vendors, and more.

Outsourcing ends at supplier selection and documented agreement.

Goals
1. Needs for outsourcing are determined. (*BP 05.01)*
2. Qualified suppliers are selected to provide solution or process components. *(BP 05.02, BP 05.03, BP 05.04)*
3. A productive communications environment is established and maintained with potential suppliers. *(BP 05.05)*

Notes
The general term "supplier" is used to identify an organization that develops, manufactures, installs, tests, supports, or otherwise provides products or services. Suppliers may take the form of development contractors, support contractors, product suppliers, partners, other government entities, off-the shelf item vendors (including credit card purchases), etc., according to the acquirer's needs.

The acquirer establishes a cooperative partnership environment between itself and potential and contracted suppliers to ensure suppliers understand the needs of the acquirer and the acquirer understands the capabilities and limitations of the suppliers. This environment provides a sound basis for selecting a set of potential suppliers that is qualified to meet the needs of the acquirer. This usually means a supplier can be selected that will maximize the potential success of the delivered product or service.

Relationships between this PA and other PAs

Outsourcing provides product and service elements and parts based on inputs from Design (PA 03), Design Implementation (PA 06), and Operation and Support (PA 10). Monitoring of outsourced elements is provided by Project Management (PA 11). Training (PA 22) and/or skills may be outsourced as determined by Project Management. Specific activities pertaining to managing the agreements are addressed in Supplier Agreement Management (PA 12). Decisions made as a part of this process area should be made in accordance with the Alternatives Analysis process area (PA 04). Requirements allocated and communicated to the potential suppliers are those identified in Requirements (PA 02) and Design (PA 03). Supplier evaluation criteria are related to Evaluation (PA 08). Practices of Integrated Teaming (PA 14) enable the effective implementation of each of the outsourcing activities and eventual Supplier Agreement Management. Measurement requirements relating to outsourced products and services are obtained via the practices of the Measurement and Analysis process area (PA 18). Received product and service elements are integrated with other elements according to the practices of Integration (PA 07). Risks associated with outsourcing are referred to the practices of Risk Management (PA 13).

Project Management (PA 11) activities determine the needed skills when planning the project, ensure skills are available for the project either through planning for training resident staff, or through obtaining those skills from external sources using practices of Outsourcing (PA 05) and Supplier Agreement Management (PA 12).

Base practices list

BP 05.01 **Identify needed products or services**: Identify needed solution or process components that may be provided by other/outside organizations.

BP 05.02 **Identify competent suppliers**: Identify suppliers that have shown expertise or capability in the identified areas.

BP 05.03 **Prepare for the solicitation or tasking:** Prepare for the solicitation/tasking and the selection of a supplier, including objective review of estimates of cost for the services/products to be outsourced, a clear description of tasking, and inclusion of evaluation criteria in the solicitation/tasking package.

BP 05.04 **Choose supplier**: Choose suppliers in accordance with the selection strategy and criteria.

BP 05.05 **Communicate with suppliers**: Establish and maintain communication with suppliers emphasizing the needs, expectations, and measures of effectiveness held by the acquirer for the solution or process components that are being acquired.

BP 05.01 Identify needed products or services

Identify needed solution or process components that may be provided by other/outside organizations.

Description
Rarely does an organization make every component of a system or have every skill needed to provide a service. Make-versus-buy analyses and decisions determine which items will be procured. Needs that will be satisfied outside the organization are generally those in which the acquirer has little expertise or capability. Those needs are identified for outsourcing.

Typical Work Products
- make-versus-buy analysis
- trade study
- list of system components
- subset of products or services to be outsourced
- beginnings of criteria for completion of needed work
- skills needed

Notes
The Alternatives Analysis process area (PA 04) addresses decision-making processes that may be used.

Example practices include:
- perform trade study
- examine own organization to determine missing expertise needed to address requirements

Additional Practice Guidance
- Perform trade studies to determine make-versus-buy decisions based on business needs.
- Perform cost-benefit analysis for commercial off-the-shelf versus in-house developed environments.
- Establish a mechanism for assessing existing designs and specifications for reuse in new applications.

BP 05.02 Identify competent suppliers

Identify suppliers that have shown expertise and capability in the identified areas.

Description
The capabilities of the supplier should meet the needs of the acquirer. Issues that may be of concern include competent development processes, manufacturing processes, responsibilities for verification, on-time delivery, life-cycle support processes, historical performance, process capability, ability to perform the work, and ability to communicate effectively over long distances (video teleconferencing, electronic file transfers, e-mail and the like). The custom-made supplier's processes are appraised according to the project's acquisition process.

Typical Work Products
- qualified or preferred suppliers list
- qualified vendors list
- supplier expertise and capacity or capability analysis
- process capability appraisal findings/results

Notes
Example practices include:
- use trade journals
- review stock market
- use available library services
- use organizational knowledge-base (perhaps an on-line system)
- consider existing organizational experience with supplier and lessons learned
- use External FAA-iCMM Appraisal Method appraisal

Identifying competent suppliers or vendors is part of pre-evaluation activities.

Additional Practice Guidance
- Select suppliers based upon input from the appropriate stakeholders.

BP 05.03 Prepare for the solicitation or tasking

Prepare for the solicitation/tasking and the selection of a supplier, including objective review of estimates of cost for the services/products to be outsourced, a clear description of tasking, and inclusion of evaluation criteria in the solicitation/tasking package.

Description
During the pre-solicitation or pre-selection period the acquirer prepares for the selection of a supplier through a series of actions. The principal actions are the development of an acquisition strategy including a selection strategy and a solicitation approach to satisfy the needed components/services identified in BP 05.01. The acquisition strategy provides for the type of competition, selection, incentives, and contract type. The solicitation approach details the activities and documents necessary to perform the selection, including evaluation criteria and statement of work. The solicitation package is then issued to the identified potential suppliers.

Typical Work Products
- acquisition strategy
- selection strategy
- solicitation package, including:
  - contract clauses
  - requirements
  - constraints
  - statement of work
  - evaluation criteria
  - evaluation plan
  - list of potential suppliers
  - contract documentation including specifications, test plans, etc.
- purchase request
- request for proposal

Notes
The selection of a supplier must be planned based on a number of factors: requirements, cost, schedule, risks, capability of the supplier, best value, past performance, etc. The qualified candidates list identified in BP 05.02 is an input for this phase.

The selection strategy is differentiated from the acquisition plan of Project Management (PA 11) in that the strategy is specific to the instant solicitation. The practices of Alternatives Analysis (PA 04) are used to help prepare the evaluation plan. The requirements (including key requirements and measures) allocated to the potential contractor are incorporated into the solicitation and are consistent with those requirements identified in Requirements (PA 02) and Design (PA 03).

Expectations will ultimately be documented in a contract that typically includes:

- terms and conditions
- statement of work
- requirements for the products and services to be provided
- list of dependencies between the supplier and the acquirer
- conditions under which revisions to products are to be submitted
- acceptance procedures and acceptance criteria to be used in evaluating supplier products
- procedures and evaluation criteria to be used by the acquirer to monitor and evaluate the contractor's performance
- requirements for periodic reporting by suppliers on planned COTS product changes, new releases, end of production dates, end of support dates, upward/downward compatibility of new products, etc.

Additional Practice Guidance

- Formally document requirements for the work.
- Establish formal criteria for the reuse and commercial off-the-shelf (COTS)/internal development decision process.
- Establish a mechanism for applying business goals to the evaluation of internal development of technologies versus those externally available.
- Assess current processes to see if they adequately support a COTS solution.

BP 05.04 Choose supplier

Choose suppliers in accordance with the selection strategy and criteria.

Description
Suppliers are selected in a logical and equitable manner to meet product or service objectives. The characteristics of a supplier that would best complement the acquirer's needs are evaluated, and qualified candidates are identified. Suppliers are selected based upon evidence of their ability to perform the work as defined by the requirements. The practices of the Alternatives Analysis process area (PA 04) are applied to select the appropriate supplier. An agreement is documented and accepted by the appropriate parties.

Typical Work Products
- selected supplier
- rationale for selecting supplier
- awarded contract
- interagency agreement
- memorandum of understanding

Notes
An important consideration in the selection of the supplier is the expected working relationship. This could range from a highly integrated product team to a classical "meet the requirements" relationship. The selection criteria are likely different, depending on the desired relationship. The contractor and acquirer must have a shared vision.

The Alternatives Analysis process area (PA 04) addresses decision-making processes such as supplier selection.

The documented agreement may be in the form of a contract, interagency agreement, memorandum of understanding, bill of sale, etc.

Additional Practice Guidance
- Select suppliers based upon input from the appropriate stakeholders.
- Selection shall also take into account the supplier’s quality system.

BP 05.05 Communicate with suppliers

Establish and maintain communication with suppliers, emphasizing the needs, expectations, and measures of effectiveness held by the acquirer for the solution or process components that are being acquired.

Description
The acquirer and supplier establish and maintain a mutual understanding through effective, timely, and appropriate communications. The acquirer must clearly identify and prioritize its needs and expectations, as well as any limitations on the part of the suppliers. The acquirer works closely with suppliers to achieve a mutual understanding of product requirements, responsibilities, and processes that will be applied to achieve program objectives. There is a clearly negotiated and documented agreement that contains the statement of work, specification, terms and conditions, list of deliverables, schedule, budget, measures of effectiveness, and acceptance process. The supplier is involved as early as feasible in the program to assist in requirements development and definition.

Typical Work Products
- needs statement
- draft Request for Proposal
- technical performance parameters
- minutes and decisions from negotiations

Notes
Characteristics of communications include the types of information that are considered open and subject to no legal restrictions, the types of information subject to legal restrictions (e.g., policy or contractual relationships), the expected timeliness of information requests and responses, tools and methods to be used for communications, security, privacy, and distribution expectations. "Face-to-face" versus "at a distance" communication is important.

Expectations are documented in a contract that typically includes:
- terms and conditions
- statement of work
- requirements for the products and services to be provided
- list of dependencies between the supplier and the acquirer
- conditions under which revisions to products are to be submitted
- acceptance procedures and acceptance criteria to be used in evaluating supplier products
- procedures and evaluation criteria to be used by the acquirer to monitor and evaluate the contractor's performance
- periodic reporting by suppliers on planned COTS product changes, new releases, end of production dates, end of support dates, upward/downward compatibility of new products, etc.

Examples of techniques and forums for providing needs, expectations, and measures of effectiveness to suppliers or vendors include:

- trade studies
- advertisements
- draft contracts
- draft statements of work
- specifications
- joint meetings

Additional Practice Guidance

- Develop and use a mechanism for establishing and nurturing long-term relationships with preferred suppliers.

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PA 06: Design Implementation

Process Area Summary

Purpose
The purpose of the Design Implementation process area is to produce a specified solution component.

Major points addressed
This process incorporates the development of a solution component based on its design specification and according to its interface requirements and implementation constraints. The solution component is constructed by processing the materials, services and/or information appropriate to the selected implementation technology and by employing appropriate technical specialists or disciplines.

Solution components are developed product elements that will be used by the Integration process area (PA 07). The examination of alternative solutions, with the intent of supporting the optimum design based upon agreed 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.

All supporting solution component documentation is produced with defined detailed procedures and criteria for integration of the solution components.

Goals
1. Solution component(s) are developed. *(BP 06.01, BP 06.02)*
2. Documentation to support solution component(s) is established and maintained. *(BP 06.03)*

Notes
This PA focuses on development of a specific solution component as a single element of a product or service. Solution components are developed based upon an individual design element that will be fabricated in support of the overall product or service.

Relationships between this PA and other PAs
This PA assumes that the requirements have been clearly documented and are unambiguous, verifiable, and traceable to the individual solution components according to the practices of Requirements (PA 02). Transition, Deployment, and Disposal (PA 09) activities interact with Design Implementation activities via the Design (PA 03) process area to assure that the implementation is compatible with transition, deployment, and disposal considerations. This PA also requires that the design specification has been completed according to practices of Design (PA 03) in order to document and implement the individual required solution component. Integration (PA 07) is dependent upon the successful implementation of individual component solution(s). The Evaluation process

area (PA 08) is utilized to evaluate individual solution components as they are built. Implemented components and the supporting infrastructure are controlled using the practices of Configuration Management (PA 16). The examination of alternative solutions, with the intent of supporting the optimum design based upon agreed criteria, is expected. The practices of Integrated Teaming (PA 14) provide a collaborative approach for involving the individuals and organizations engaged in accomplishing the practices of this PA. Operation and Support (PA 10) induced changes are implemented after processing by the activities of Requirements (PA 02) and Design (PA 03). Design implementation depends on Outsourcing (PA 05) for material acquired and on Innovation (PA 23) for resolution of manufacturing and production issues.

Base practices list

BP 06.01 **Establish the implementation environment:** Establish the methods, standards, and tools to be used to implement the solution component(s) strategy.

BP 06.02 **Formulate product or service components**: Formulate solution components according to the specifications.

BP 06.03 **Develop documentation**: Develop and maintain the documentation that will be used to operate and maintain the product or service components.

BP 06.01 Establish the implementation environment

Establish the implementation environment including the methods, standards, and tools used to implement the solution component strategy.

Description
This base practice involves defining implementation procedures and processes, taking account of implementation tolerances and verification uncertainties. In the case of repeated system component development, (e.g., mass production, replacement system elements) the implementation procedures and processes are defined to achieve consistent and repeatable production.

This includes establishing an environment that is conducive to solution component creation and supports the implementation of integrating solution components of a product or service. Document the rationale for selecting each tool or method, and place the tools used to develop and maintain the product or service components under configuration management. These will be essential inputs to begin the integration process.

Typical Work Products
- solution components inventory
- description of component(s)
- selected methods and tools used to develop solution component(s)
- rationale for selecting tools, methods, and component(s)

Notes
Candidate methods and tools are selected based upon applicability to the organization's standards, the project's selected processes, the existing skill base, availability of training, contractual requirements, capability, ease of use, and support services.

The configuration management methods and tools used should integrate well with other selected methods and tools. (Refer to the Configuration Management (PA 16)).

For software components, the software code is developed and documented according to the project's software process, to implement the software requirements and software design.

BP 06.02 Formulate product or service components

Build solution components that will be used to implement the product or service.

Description
Implement the product or service component(s) based upon solution description specifications including design constraints, interface constraints, and allocated requirements that are necessary and sufficient to produce or acquire an element that is capable of meeting all validation and verification conditions. Implementation of a component is used either as the basis for further implementation of that component or for outsourcing that component. At the lowest layer of design, the component (element) design specifications provide the essential conditions for construction of the element. There are vast categories of component design constraints and requirements, typically including constraints imposed by selection of another design component, that need to conform to another design component interface and to allocated design level functional, performance, and interface requirements.

Typical Work Products
- component
- software code units
- circuit board(s)
- service components
- peer review results
- subsystem constraints
- solution component(s)/elements
- service components/element(s)
- hardware solution component(s)/element(s)
- software solution component/element(s)
- solution component/element(s) specifications
- solution component/element(s) documents

Notes
The solution component is dependent upon a design specification or other collection of information that fully describes a solution component(s) or its interface in terms of all the constraints and design requirements placed on the component. The individuals involved in implementation must review the requirements and design to ensure that issues affecting the implementation are identified and resolved. Use effective methods to implement the product or service solution component(s). The sequence in which units are developed must account for factors such as criticality, difficulty, integration and test issues, and needs of the customer and end users, as appropriate. Each solution component must meet the exit criteria of the chosen implementation methodology before it is considered complete.

For hardware fabrication, fabricate hardware components using the conditioning, forming, and fabrication techniques relevant to the physical implementation technology

and materials selected. As appropriate, hardware components are tested to confirm specified product quality characteristics.

For software creation, code software components and, as appropriate, compile and inspect to assure conformance to the design criteria specified in the data package. A system component including configuration and performance data is produced.

Place the product or service solution components under configuration management (refer to Configuration Management (PA 16)), and make appropriate changes to the solution components whenever the requirements or design changes may affect the individual solution component.

BP 06.03 Develop documentation

Develop and maintain the documentation that will be used to operate and maintain the solution components of the product or service.

Description
Establish and maintain documentation from the developed solution component(s) data packages, and define detailed procedures and criteria for integration of the solution components. Use appropriate methods and tools to develop the documentation. Documentation specialists must actively participate in planning, developing, and maintaining documentation. Develop and make available preliminary versions of the documentation early in the solution component development life cycle for the customer, end users, and maintainers to review and provide feedback. Verify final versions of the documentation against the solution components that will be used in acceptance testing. Evaluations such as peer reviews of the documentation should be performed.

Manage and control the documentation. The final documentation must be reviewed and approved by the customer, end users, and maintainers, as appropriate. The documentation that will be used to operate and maintain the components is developed and maintained according to the project's processes.

Typical Work Products
- training documentation
- on-line documentation
- user’s manual
- operator’s manual
- maintenance manual
- peer review results
- parts list
- inventory components

Notes
Examples of methods and tools include:
- word processing
- case studies
- documentation reuse

Examples of documentation include:
- training documentation
- on-line documentation
- user's manual
- operator's manual
- maintenance manual

PA 07: Integration

Process Area Summary

Purpose
The purpose of Integration is to ensure that product and service elements will function as a whole.

Major points addressed
This process area emphasizes integration strategy and preparation, interface coordination and maintenance, confirmation that product and service elements are ready and available for integration, and confirmation that the integrated product or service is ready for evaluation. Integration activities begin early in the development effort when the integration strategy can be influenced by all engineering disciplines and applicable interface requirements, and standards can be invoked. Interface coordination is conducted throughout the life cycle. Integration readiness is assured through coordination of interface definition and confirmation that product and service elements are qualified (inspected and evaluated) and available. Products and services are integrated and their readiness for test and evaluation determined.

Goals
1. A strategy for integrating the product and service elements is defined and communicated. *(BP 7.01)*
2. Readiness of product and service elements for integration is verified. *(BP 7.02, BP 7.03)*
3. The product or service is integrated in accordance with the integration strategy. *(BP 07.04, BP 07.05)*

Notes
Product integration is more than just a one-time assembly of product elements at the conclusion of design and fabrication. It is usually advantageous to conduct integration incrementally, using an iterative process of "build-test-build." Integration may be facilitated through the use of a prototype/testbed that allows for the gradual replacement of simulated elements by fully functional elements. The process may begin with analysis and simulation (e.g., threads, rapid prototypes, mechanical prototypes) and steadily progress through increasingly more realistic incremental functionality until the final end product or service is achieved. In each successive build, prototypes are constructed, tested, improved, and reconstructed based upon knowledge gained in the testing process. A successful integration strategy should use combinations of these techniques in an incremental manner. There is a high probability that the end product, integrated in this manner, will pass verification and validation. Similar considerations apply to integration of service elements.

Relationships between this PA and other PAs

The integration strategy and sequencing is coordinated with the planning and scheduling practices of Project Management (PA 11). Product and service elements are received from Design Implementation (PA 06) or Outsourcing (PA 05) and verified in accordance with practices of the Evaluation process area (PA 08) prior to integration. Coordinating, reviewing and maintaining the integrity of interface definitions, developed in Design (PA 03), is interdependent with Configuration Management (PA 16) and Integrated Teaming (PA 14). Problems or issues identified during integration are input to Project Management (PA 11) and Risk Management (PA 13). The practices of Evaluation (PA 08) are performed on elements and on the integrated product and service. The coordination and communication needed for Integration are supported by the practices of Integrated Teaming (PA 14). Implementation changes induced from any source, including Operation and Support (PA 10), are re-integrated into the product or service according to the practices of the Integration PA.

Base practices list

BP 07.01 Develop integration strategy: Develop an integration strategy and supporting documentation that identify the sequence for receipt, assembly, and activation of the various elements that make up the product or service.

BP 07.02 Confirm readiness of product and service elements: Confirm the readiness of each product and service element in accordance with the integration strategy schedule and quality standards.

BP 07.03 Review and coordinate interface definitions: Review and coordinate product and service element interface definition, design, and change between affected groups and individuals throughout the life cycle.

BP 07.04 Assemble product and service elements: Assemble or integrate product and service elements in accordance with the integration strategy.

BP 07.05 Confirm integrated product or service operation: Confirm that the integrated product or service functions to the extent required for evaluation.

BP 07.01 Develop integration strategy

Develop an integration strategy and supporting documentation that identify the sequence for receipt, assembly, and activation of the various elements that make up the product or service.

Description
Using business as well as technical factors, a strategy is developed for receipt, assembly, activation, and integration of the product and service elements. The larger or more complex the system or the more delicate its elements, the more critical the proper sequence becomes, as small changes can cause large impacts on project results. Selection of an integration sequence considers risk, planned element readiness, and ease of fault isolation during operational checkout of incremental assemblies. Communicate the strategy to all stakeholders.

Typical Work Products
- Integration Strategy Document containing
  - schedules for integration activities and element readiness
  - personnel requirements
  - special shipping and handling of elements
  - system documentation for systems engineering users
  - assembly sequence and rationale
  - procedures
  - communications
  - service element checkout sequence

Notes
Alternative sequences should be considered and an appropriate assembly sequence selected based on characteristics of the services, subsystems or components, such as the technical risk associated with the various elements.

In developing an integration strategy for services, the availability of service staff, their qualifications and training, service element interface procedures, problem resolution procedures, facilities, and tools (e.g., desktop computers and other equipment) should be considered. Integration strategy should also consider maintenance arrangements or contracts for the service infrastructure (e.g., communications equipment, data storage and retrieval resources, office or laboratory equipment).

For hardware/software product integration, a typical assembly sequence is an initial assembly of user interface, data base and communication infrastructure, followed by serial inclusion and test of higher-risk subsystems, such as a new suite of computational or graphical components. A fundamental consideration for evaluating alternative sequences is to select a sequence that reduces the diagnostic effort of fault isolation. The selection of a sequence will take into consideration any effort needed to establish and equip the assembly facilities (e.g., raised floor, hoists, jigs, test equipment, input/output,

and power connections). Once established, the sequence must be periodically reviewed to ensure that variations in production and delivery schedules have not had an adverse effect on the sequence or compromised the factors on which earlier decisions were made.

Component risk notwithstanding, general sequence of assembly is from the bottom up as components become sub-elements, elements, and subsystems, each of which must be checked prior to fitting into the next higher assembly.

The integration strategy should also consider requirements and plans for site preparation and the installation and integration (I&I) activities conducted at development/test sites or operational field facilities. For these activities, the integration strategy must address the proper preparation of each implementation site to ensure readiness for I&I. Readiness includes assurance that all system elements and associated interfaces function correctly, assurance that the integrated system can be connected to external systems without causing degradation, and verification of the correct operation of the installed system when operating in conjunction with other interconnecting systems.

Additional Practice Guidance

- As part of the integration strategy, include contingency plans to minimize the impact on subsequent project schedules/costs in the event of delays in availability of various subsystems.
- Define detailed procedures and criteria for integration of the product components.
- Establish requirements and plans for the environment needed to support the integration of the product components
- Use a common support environment for integration and verification.

BP 07.02 Confirm readiness of product and service elements

Confirm the readiness of each product and service element in accordance with the integration strategy schedule and quality standards.

Description
The goal of confirming readiness is to assure that each element of the product or service is received, checked for quality, and available as required to support the integration schedule. This includes checking for receiving reports and for evidence that elements were checked for quantity, obvious damage, and consistency between the element description and a list of element requirements. Service element readiness includes confirming that service provider staff are ready, their organization and procedures are ready, and appropriate contractual conditions are in place.

Typical Work Products
- confirmation of receiving, acceptance, and/or evaluation documents
- confirmation of supplier quality assurance documents
- delivery receipts
- checked packing list
- report of element readiness deficiencies that may affect the integration schedule
- confirmed availability of service elements
- confirmation of service element procedures

Notes
Examples of activities to confirm the receipt and quality of service elements include contacting staff to confirm their schedules and availability, confirming the existence and approval status of inter-element coordination procedures, reviewing staff training reports, reviewing staff qualifications, and monitoring availability and/or installation of service infrastructure facilities/equipment. Confirmation of facilities and equipment should include maintenance agreements.

Technical evaluation of developed or non-developmental items is performed according to the practices of the Evaluation process area (PA 08). Evaluation (e.g., test) reports are confirmed by practices of integration. Suppliers should provide a quality assurance document, for example, a quality system acceptance report, describing the quality assurance acceptance criteria, including vendor testing and evaluation method, metrics, assessment criteria, and instrumentation with environmental conditions that were adhered to during acceptance and delivery of the product or service.

It is vital for safety-critical products, particularly those that are or include commercial-off-the-shelf and non-developmental-items, that a means be provided to ensure that product elements, and their component parts, are produced by the appropriate manufacturer(s) or supplier(s).

Additional Practice Guidance

- Track the delivery status of elements to be integrated.
- Check the list of required items to verify delivery of the expected items.
- Ensure that product components and interfaces are marked to ensure easy and correct connection to the joining product component.
- Monitor and track schedule readiness progress for service elements.

BP 07.03 Review and coordinate interface definitions

Review and coordinate product and service element interface definition, design, and change between affected groups and individuals throughout the life cycle.

Description
The completeness and accuracy of product and service interfaces evolves through development, operation, and maintenance of the product. Experience indicates that during development, an on-going effort dedicated to review and coordination of interfaces is cost effective in reducing end-item integration and verification problems. During operations and maintenance, interface issues are input to the configuration management change analysis process (including assessment of impacts to potential interface changes). Interface review and coordination activities include confirmation that interface documents adhere to standards for form and content. An on-going effort to review and coordinate interface specifications must be pursued to reduce the risks to successful product integration and verification.

Typical Work Products
- interface review status
- interface issues
- analysis of COTS interface documentation
- analysis of re-use component interfaces
- interface risk items
- minutes of interface control working groups

Notes
Interface coordination for service elements includes confirming that qualified and approved inter-element (e.g., inter-departmental) procedures have been reviewed and approved and that interfaces to service infrastructure have been prepared and coordinated. An example of the latter would be procedures for appropriate configuration of desktop computer user interfaces in accordance with service staff roles, responsibility, and authority.

In the case of hardware/software products, external interface specifications are often outside the control of the project and may be either initially incomplete or inaccurate. Commercial off-the-shelf product literature and documentation are frequently incomplete or incorrect.

Additional Practice Guidance
- Establish and use checklists for interface reviews that address completeness and accuracy.
- Establish a common set of data requirements for interface documentation (e.g., stimulus, protocol and data characteristics, timing, electrical properties, mechanical drawings).

- Establish interface control working groups as a means of resolving interface issues and monitoring interface development progress.
- Systematically map and assess each component against all other components to assure that all interfaces have been identified.

BP 07.04 Assemble product and service elements

Assemble or integrate product and service elements in accordance with the integration strategy.

Description
Product and service elements are assembled into larger or more complex assemblies in accordance with the planned integration strategy. Evaluation of the integrated product and/or service is explicitly addressed in Evaluation (PA 08).

Typical Work Products
- integration reports
- exception reports
- integrated product

Notes
Examples of product element assembly include:
- subsystem build
- subsystem checkout
- integration of software units into computer system configuration items

Examples of service element integration include::
- practice runs of service element procedures
- confirmation of service element interfaces with the environment

BP 07.05 Confirm integrated product or service operation

Confirm that the integrated product or service functions to the extent required for evaluation.

Description
Confirmation of functional readiness for product or service evaluation (e.g., product or service verification) involves checking that the elements and interfaces respond to appropriate stimuli and that no unexpected behavior exists that indicates product or service destructive behavior or safety concerns.

Typical Work Products
- integration anomaly reports
- installation and integration checklist/reports
- integrated product ready for verification
- installation integration test reports
- integration strategy/planning change requests

Notes
Integration checkout includes checking for functional response to user inputs and to inputs from other products or systems. The complete range of functions should be checked for operation, but not for performance. Checking the partially assembled product at each stage of the planned integration sequence aids in isolating faults. The activity of integration checkout is often combined with a practice run of product verification. Product integration evaluation may share test procedures, support items, and facilities with product verification activities. Comprehensive product evaluation against all requirements is explicitly addressed in the Evaluation process area (PA 08).

Integration checkout of a service may involve practice runs of procedures to confirm the readiness of the procedures and the availability of appropriate staff to execute the procedures. Service checkout often involves providing a simulation to input service requests and receive service actions. In the case of an air traffic control service, simulated aircraft tracks may need to be provided. Emergency services integration checkout may involve simulated accidents or other emergency events, including simulated equipment damage or personnel injuries.

Additional Practice Guidance
- Ensure integrated functionality and readiness for evaluation in all states and modes.
- Record all appropriate information (e.g., configuration status, serial numbers of the elements, types and calibration date of the meters).

PA 08: Evaluation

Process Area Summary

Purpose
The purpose of Evaluation is to confirm that developed and acquired products and services satisfy specified requirements and operational needs, and identify and document actual and potential defects in evolving product and service elements.

Major points addressed
The Evaluation process area addresses evaluations of all work products and service elements including incremental and end-result products and services. Evaluation activities include both validation and verification.

Development of the evaluation approach/strategy and technical and non-technical evaluation requirements begin early and run concurrently with analysis and understanding of the product or service needs and requirements. Verification evaluations (including test) are performed on incremental, acquired, and end-item products and services to confirm they satisfy requirements. Validation evaluation is performed on products and services to confirm they fulfill their intended use in their intended environment. Incremental evaluation includes formal reviews, peer reviews, audits and functional demonstrations for verification of product and service elements against requirements. Evaluation results are analyzed to identify non-conformances to the product or service requirements. These non-conformances are documented and corrective actions are assigned and tracked until they are resolved.

Evaluation activities are performed over the complete life cycle of products and services, from evaluating the quality of needs and requirements through evaluation of product and service retirement. Product and service evaluations are supported by an appropriate evaluation environment, including trained and qualified evaluators, calibrated test equipment, hardware and software test drivers, sub-system simulators, test scenarios, and facilities.

Goals
1. The evaluation approach, requirements, methods, and environment are established to provide an objective basis for determining whether the products and services meet requirements and can be accepted. *(BP 08.01, BP 08.02, BP 08.03)*
2. Evaluations are performed as planned. *(BP 08.04, BP 08.05 BP 08.06)*
3. Analyses are conducted on results of evaluations to support acceptance or corrective actions. *(BP 08.07)*

Notes
The term “validation” in this PA follows common industry standard usage and denotes confirming or ensuring that the intended use for a product or service is fulfilled in the intended usage or operational environment. In the iCMM, the intended use is described in work products developed in the Needs process area (PA 01) (such as operational concepts, operational scenarios, and statements of needs and expectations). Validation demonstrates that the product

or service actually performs its intended function in its intended environment, thus addressing stakeholder needs and expectations in the "real world." The phrase "validating against needs" denotes this activity. Validation addresses the questions: "Did I build or acquire the right product/service? Is this what I really need? Is this what I expected, now that I am actually using it?"

"Verification" denotes confirming or ensuring that specified requirements for a product or service have been fulfilled. In the iCMM, the requirements are developed in the Requirements process area (PA 02); component design specifications are developed in the Design process area (PA 03). These are all based on, and trace back to, the needs and expectations of the customers and other stakeholders, as determined in the Needs process area (PA 01). Verification addresses the questions: "Did I build the product/service right? Does this product/service fulfill its stated requirements?" Whereas requirements are based on operational (and other) needs, a product or service may fulfill stated requirements but not necessarily perform as expected in the intended environment; thus evaluation encompasses both verification and validation activities.

The term "evaluation" is applicable to products, product elements, work products, and services. Evaluation of hardware, software, documentation, operations, and support services is accomplished through formal reviews, peer reviews, audits, tests, and demonstrations. The term "test" is often used informally to refer to certain evaluations although "test" (technically) is only one form of evaluation. The "requirements" that are the basis for verification are typically documented in product requirement specifications and sub-product design specifications. The "needs" that are the basis for validation may be documented in operational concept documents. Since the range of possible evaluation activities can be quite large and potentially expensive, cost-benefit analyses may be warranted to determine a scope of evaluation activities that provides a reasonable balance of defect removal and verification effectiveness versus cost.

Note that some organizations may focus on selected evaluation practices. For example, a test organization that performs verification testing on completed systems/products could focus and add detail relating to the base practices involving verification planning and strategy, test case and test procedure development, test environment and tools, test execution processes, data collection and reporting and analysis of test results.

Relationships between this PA and other PAs

Evaluation activities apply to the work products of all process areas. Evaluation strategies and activities should be coordinated with those of Quality Assurance and Management (PA 15) to ensure they are complementary. Quality Assurance and Management will typically be accomplished by sampling products and processes throughout the life cycle. Quality Assurance and Management provides an objective view that ensures the integrity of product and service evaluations and the implementation of planned processes. Evaluation is the verification and validation of products and services against their technical requirements and needs.

Requirements (subject to evaluation) mentioned in this process area are defined in the Requirements (PA 02) and Outsourcing (PA 05) process areas. Validation evaluations are based on needs determined in the Needs (PA 01) process area. Corrective actions resulting from evaluations are monitored in Project Management (PA 11), and Supplier Agreement

Management (PA 12). Integrated Teaming (PA 14) supports the establishment of evaluation teams to accomplish product and service evaluation. The Evaluate Incremental Work Products base practice (BP 08.04**)** of this process area is used to verify that stated product and service requirements (from PA 02) meet established quality criteria (e.g., unambiguous, complete, traceable, feasible, and verifiable).

Base practices list

BP 08.01 **Develop evaluation strategy**: Establish and maintain a comprehensive strategy and requirements for evaluating products and services throughout their life cycle.

BP 08.02 **Develop evaluation procedures**: Develop the detailed procedures, methods, and processes to be used in evaluating products and services.

BP 08.03 **Establish and maintain evaluation environment**: Establish and maintain the tools, facilities, personnel, documentation, and environment needed to perform planned evaluations.

BP 08.04 **Evaluate incremental work products:** Evaluate incremental work products and services.

BP 08.05 **Verify end-products:** Evaluate end-products and services against specified requirements.

BP 08.06 **Validate end-products:** Evaluate the capability of end-products and services to fulfill their intended use in representative operational environments.

BP 08.07 **Analyze evaluation results:** Analyze results of evaluations and compare them to the needs and requirements to identify and quantify deficiencies, and recommend corrective and preventive actions.

BP 08.01 Develop Evaluation Strategy

Establish and maintain a comprehensive strategy and requirements for evaluating products and services throughout their life cycle.

Description
Evaluation requirements are both technical and non-technical (e.g., requirements on how and when evaluations are to be performed), and include identification of products and services to be evaluated. A comprehensive evaluation strategy includes evaluation of evolving work products (e.g., formal and informal reviews such as design reviews and peer reviews), evaluation of acquired products, elements and services, evaluation of end-products and services against their requirements, and evaluation of end-products and services against needs in a representative operational environment. The evaluation strategy should include methods that have proven effective for identifying defects and for confirming that requirements have been satisfied. For example, if alternative methods to peer reviews are used to identify defects and deficiencies in incremental work products, the alternative methods should be at least as effective as industry practices for peer reviews.

The evaluation strategy must be documented for each identified product or service. The documentation should include the objectives of the evaluation(s), acceptance criteria, evaluation methods, responsibility for each evaluation, resources, facilities, special equipment, and evaluation schedule. The evaluation strategy should identify review points in the development span of work products that provide for relatively efficient detection and removal of defects (e.g., peer reviews at 20 percent and 80 percent levels of completion)

Typical Work Products
- requirements and methods for peer reviews
- list of types of work products for which peer reviews are required
- identification of the types and range of project evaluation activities
- evaluation methods for maintenance services
- requirements for evaluation plans for selected evaluation activities (e.g., Verification Plan, Validation Plan, Verification Plan for acquired products and services)
- test sections of an integrated program plan, statement of work, acquisition strategy, or performance baseline
- test and evaluation guide
- strategy for the evaluation of products and services
- identification of appropriate stakeholders for selected evaluation activities
- requirements and methods for receiving inspections
- requirements for analysis and documentation of evaluation results
- project test milestone schedule

Notes
The evaluation strategy (often referred to as the test and evaluation strategy) typically begins early, with the definition of product and service requirements to ensure that these requirements are verifiable. The strategy includes ensuring that an appropriate method of verification (e.g., test, analysis, or inspection) is assigned to each requirement. Product and service evaluation is an on-going process that occurs throughout development or acquisition. It begins with evaluation of the quality of the requirements and other work products, progresses through the evaluation of elements and the integrated product or service, and ends with the operation of products or services in the intended environment. Due to the large number of considerations associated with establishing an evaluation strategy and developing evaluation requirements, tools that support the development of the strategy should be archived. Examples of tools include checklists, templates, lessons learned, etc.

Verification involves evaluating products or services against documented requirements; validation involves evaluation of products and services against customer/user needs in a representative operational environment.

Additional Practice Guidance
- Include the following in the evaluation strategy and requirements:
  - schedules or schedule requirements for the selected types of evaluation
  - peer reviews of requirement, design, and test documents
  - reviews of supplier documentation
  - testing of in-house and acquired components, prior to integration
  - evaluation methods for the selected types of evaluations to be employed on the project
  - end-product and service verification
  - end-product and service validation
  - tools and facilities for evaluation
  - calibration or “proofing” of test support software and equipment
  - participation in supplier reviews
  - identification and notification of appropriate review stakeholders
- Incorporate an evaluation strategy for performing evaluations at the appropriate phase in development of elements and products (e.g., at a time for efficient defect removal).
- Provide for evaluation planning with sufficient lead time to acquire and prepare the evaluation tools, facilities and environment.
- Allow for reuse of evaluation resources (e.g., test equipment, test software, and facilities) in the project evaluation strategy.
- Consider an evaluation strategy that includes validation of incremental products, e.g., at the end of each phase of spiral development.
- Provide for failure and/or non-conformance prediction in the evaluation strategy.

BP 08.02 Develop evaluation procedures

Develop the detailed procedures, methods, and processes to be used in evaluating products and services.

Description
Development of evaluation procedures includes documenting the detailed procedures, acceptance criteria, and method of handling non-conformances, for the full range of project evaluations (e.g., for design reviews, peer reviews, supplier evaluations, element verification, end-product verification, and validation). Evaluation procedures should define detailed methods including test case scenarios, specification of test inputs and drivers, reference to initial state of the product under test and the test environment, and expected results and tolerances for each test step.

Typical Work Products
- peer review procedures and reportable defect categories
- test procedures, test scripts, and acceptance criteria
- service evaluation procedures and evaluation assessment criteria
- formal review procedures and agenda
- acquired product and service test procedures and criteria
- system verification procedures and test cases
- simulation requirements
- verification scenarios
- validation procedures and test cases
- operational scenarios

Notes
Evaluation procedures are typically organized into evaluation (test) cases that represent realistic operational scenarios. These operational scenarios are based on the operational scenarios and sequences developed in the determination of needs and requirements phases.

Additional Practice Guidance
- Define and maintain traceability between items or services being evaluated and their requirements.
- Establish appropriate measures for service evaluation (e.g., “needs improvement,” “acceptable,” “exceeds expectations”).
- Define the documentation requirements for evaluation activities and results (e.g., templates for test procedures and forms for anomaly reporting).
- Identify the expected results and any tolerances allowed in the observation and other criteria for satisfying the requirements.
- Review verification plans early with peers within the developer’s organization and with other system stakeholders to assess risky aspects of system development and to agree on alternative courses of action in the event of failures while conducting verification.

BP 08.03 Establish and maintain evaluation environment

Establish and maintain the tools, facilities, personnel, documentation, and environment needed to perform planned evaluations.

Description
Evaluation environments and resources, appropriate to the needs of selected evaluation activities, are established to enable successful product and service evaluations. These range from meeting rooms, processes, and desktop computers for peer reviews to laboratories, test equipment, test software, and simulators for element and product verification and validation. Evaluation preparation includes consideration of test equipment and software acquisition, calibration and/or validation of test support hardware and software, and analysis tools.

Typical Work Products
- test and certification laboratories
- test readiness review results
- test equipment and software validation and calibration results
- test tools interfaced with the product being evaluated (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 mock aircraft for testing an ATC radar)
- real interfaced systems (e.g., aircraft for testing a radar with trajectory tracking facilities)
- dedicated computing or network test environment (e.g., pseudo-operational telecommunications network testbed or facility with actual trunks, switches, and systems established for realistic integration and validation trials)

Notes
Although a peer review may require little more than a package of materials, reviewers, and a room, the efficiency of peer reviews can often be improved with appropriate tools and resources such as peer review procedures, peer review training, electronic projectors, and real-time defect data base entry. A product test may require simulators, emulators, scenario generators, data reduction tools, environmental controls, and interfaces with other systems.

Elements of the evaluation environment may be purchased developed or based on reuse. 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.

Additional Practice Guidance
- Provide approved procedures and training for peer reviews.
- Establish and maintain procedures and records for test equipment and software calibration.
- Acquire test equipment and software and items to be tested according to a comprehensive strategy that enables reuse.

- Establish and maintain documented procedures to control, calibrate and maintain inspection, measuring and test equipment (including test software).
- Define the process employed for the calibration of inspection, measuring, and test equipment, including details of equipment type, unique identification, location, frequency of checks, check method, acceptance criteria and the action to be taken when results are unsatisfactory.
- Identify inspections-measuring and test equipment with a suitable indicator or approved identification record to show the calibration status.
- Maintain calibration records for inspection, measuring, and test equipment
- Ensure that the environmental conditions are suitable for the calibrations, inspections, measurements, and tests being carried out.
- Ensure that the handling, preservation, and storage of inspection, measuring, and test equipment is such that the accuracy and fitness for use are maintained.
- Require suppliers to provide assurance of the validity and calibration of their test support equipment and software.

BP 08.04 Evaluate incremental work products

Evaluate incremental work products and services.

Description
Verify and validate incremental work products. Incremental evaluation of products, product elements, documentation and services provides for relatively efficient removal of defects and deficiencies. Peer reviews (or an equally effective alternative method of incremental work product review) should be performed at appropriate phases of work product development. Incremental evaluations include reviews of in-progress requirement, design, and element documentation and specifications, formal and informal reviews and audits, evaluation of product assemblies, and product and service elements under development. Solution components are evaluated based on design specifications and interface requirements. Standards or criteria should be established and used to specify the evaluation data to be collected and documented. Evaluation of incremental work products and services with or by the customer/user and in the intended operational environment (incremental validation) is performed at appropriate phases of incremental product and service development. The goal of evaluating developed products incrementally is to ensure that problems are found, and defects and deficiencies eliminated, as early in the development process as possible, saving the considerable cost of fault isolation, problem mitigation, and rework associated with resolving problems in a complex, integrated system.

Typical Work Products
- peer review results, for requirement, design, and code work products (see Notes below for detailed peer review work products)
- system requirement review minutes
- design review minutes
- test reports on component tests
- software unit test reports
- monthly reports of service performance evaluations
- incremental capability work product verification results
- incremental capability work product validation results

Notes
Practice runs of service elements (e.g., a customer service department, product trouble report processing function/group) can be used to evaluate the design of service solution definitions under development. These may require simulated inputs, and their evaluation procedures and analysis of results should be as rigorous as any tangible/actual product test and evaluation.

An efficient strategy should be considered for selecting the level of subsystem assembly for incremental test and evaluation. Incremental validation should be performed on partial assemblies of products and on elements (e.g., components, subsystems) when their development maturity allows operation by users (operators/maintainers) in the intended operational environment or in an appropriate representation of the operational environment. User evaluation of a software user interface is an example of incremental validation of an element. User

evaluation of integrated, but incomplete products (e.g., limited functionality and features) is an example validation of a partially completed product.

The use of the peer review method has proven to be an effective means of early defect removal. Reviews by "peers" (as opposed to reviews by supervisors or managers of work product producers) are typically effective in identifying defects, since they are conducted in a nonthreatening, collegial environment. Peer reviews should be performed on key work products including requirement, design, and test documentation, implementation activities, and specific planning work products (e.g., software development plan, risk management plan, or test plan). Incremental evaluation of requirement, design, and test work products should be accompanied by established evaluation criteria.

Peer reviews, or equally effective incremental work product reviews, should be performed well in advance of completion of work products to allow for the efficient detection and removal of defects and deficiencies, as well as on near-final work products. Peer reviews should be supported by appropriate procedures, participant roles, stakeholder lists, training, and tools. The product and service requirements, resulting from the practices of the Requirements process area (PA 02), should be verified by peer review or other effective methods to insure that the requirements meet established quality criteria (e.g., unambiguous, complete, traceable, feasible, and verifiable). They should also be validated to assure that the operational need is accurately represented in the requirements.

Peer review work products include:

- checklists of review criteria
- actions resulting from the review
- identification of the work product
- size of the work product
- size and composition of the review team
- preparation time per reviewer
- length of the review meeting
- types and number of defects found and fixed
- rework effort
- defect description
- defect category
- severity of the defect
- units containing the defect
- units affected by the defect
- activity where the defect was introduced

The following are typical peer review activities:

- Identify peers who will be the reviewers. They may include subject matter experts, stakeholders, etc.
- Ensure that the peer review leader and other participants are aware of their roles.
- Distribute review materials to reviewers in advance so they can adequately prepare for the peer review.

- Specify and enforce readiness and completion criteria for peer reviews.
- Use checklists to identify criteria for the review of the work products in a consistent manner
- Track actions identified in peer reviews until they are resolved.
- Use successful completion of peer reviews, including the rework to address the items identified in the peer reviews, as a completion criterion for the associated task.
- After peer reviews are conducted, collect, record, and analyze data about the reviews.

Additional Practice Guidance

- Include product evaluation issues (e.g., unanticipated or unintended functions or behavior) as an integral part of all formal, system-level design reviews.
- Evaluate designs prior to implementation through analysis, modeling, prototypes or simulations to gain confidence in the design functionality and robustness.
- Test new and unproven designs (i.e., highest risk) at the lowest assembly level to verify their compliance with established requirements early in the development life cycle.
- Review the incremental verification results vis-à-vis requirements with key stakeholders on an on-going basis.
- Verify system, subsystem, and work products against requirements established in an earlier phase.
- Evaluate initial, new, and changed requirements against established quality criteria, such as feasibility, verifiability, traceability, etc.
- Evaluate design specifications against established criteria.
- Evaluate design specifications for proper sequencing of events, inputs, outputs, interfaces, logic flow, allocation of timing and sizing budgets, and error definition, isolation, and recovery.
- Evaluate design specifications against safety, security, and other critical requirements.
- Validate the requirements through customer/user interaction to gain confidence that a product or service implemented in accordance with the requirements would meet the operational need.

BP 08.05 Verify end-products

Evaluate end-products and services against specified requirements

Description
Completed products and services and those acquired from external sources are evaluated against their requirements. Evaluations are supported by strategies, plans, results analysis, corrective actions, and appropriate re-evaluation. Established standards or criteria are used to specify the verification data to be collected and documented. Product test and evaluation includes any appropriate re-evaluation of products, services, sub-systems, and elements that failed initial evaluation.

Typical Work Products
- test reports
- product verification reports
- verification anomalies
- subcontractor product evaluation reports
- service performance reports
- receiving inspection for procured off-the-shelf components
- evaluation reports for off-the-shelf components

Notes
End-product evaluation includes conducting verification tests and collecting specified test data. In performing testing and re-evaluation of corrected anomalies, care should be taken to check for unanticipated effects corrective actions may have had on other product elements. A strategy is needed to determine when the entire product test suite must be re-run after anomaly corrections.

Product evaluations should include evaluations of product support documents (e.g., requirement and design documentation, quality records, user manuals, and maintenance manuals) and service and maintenance concepts. End-product evaluation (verification and validation) may include the customer as user (operator/maintainer) of the product during testing. Evaluation can include both structured and unstructured operation of the system or product by the user, and defines the type of data to be collected, analyzed, and reported.

In addition to evaluating developed, procured, and sub-contracted products against documented requirements, the products should be evaluated for useability, robustness, and likelihood of undesirable features or functionality. A product may meet all stated requirements and still exhibit undesirable behavior. Unstructured or “free form” testing using, for example, novice operators, can help assure robustness against unanticipated user inputs and actions.

External product and service element sources include customers, government agencies, public domain, suppliers, and company/organization reuse.

Additional Practice Guidance

- Maintain objective and authenticated records of verification actions and outcomes.
- Confirm that all quality plan, product, and evaluation requirements have been satisfied.
- Conduct practice runs of product verification to evaluate test procedures and processes.
- Conduct "free form" product testing using novice operators to assess product robustness against unanticipated user inputs and actions.

BP 08.06 Validate end-products

Evaluate the capability of end-products and services to fulfill their intended use in representative operational environments.

Description
Validation demonstrates that the as-built product or delivered service actually performs its intended function(s) in a representative operational environment. Validation activities use approaches similar to verification (e.g., test, inspection, analysis, demonstration, etc.). Established standards or criteria are used to specify the validation data to be collected and documented. Validation and verification activities may run concurrently and may use portions of the same environment.

Typical Work Products
- product validation anomalies
- product validation results and reports
- validation cross-reference matrix
- as-run procedures log
- service validation results
- maintainability validation results

Notes
Verification demonstrates compliance with requirements; validation demonstrates satisfactory suitability for use in the intended operating environment. In other words, verification assures "you provided the product or service right;" whereas validation assures "you provided the right product or service."

Product and service validation should be accomplished using the actual products and services operating in an environment that is as close as possible to the actual environment. 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). Validation issues may include the identification of unsatisfactory product or service requirements or unanticipated or unintended functions or behavior. Validation can occur at any point in the life cycle (e.g., during operations). Validation is often based on operational concepts and scenarios developed in the analysis of needs.

Additional Practice Guidance
- Conduct validation to detect in the product and services the existence of random and systematic non-conformance to stakeholder requirements.
- Maintain objective and authenticated records of validation actions and outcomes.
- Conduct validation with both experienced and inexperienced operators, and between operators, and assess the effects of unanticipated user inputs and actions.
- Differentiate the effects of operator training from the inherent characteristics of the product being evaluated.
- Include stress, boundary, and singular inputs in validation testing.

- Include in validation testing: graceful degradation upon failure, request for operator assistance upon stress, boundary, and singular conditions.
- Evaluate whether representative users can successfully achieve their intended tasks using the product.
- Validate that products and services satisfy their intended use.
- Conduct validation evaluation over the full range of environmental conditions.
- Provide evaluation requirements to project management and contract management for externally acquired products and services.
- Evaluate externally acquired products against requirements in accordance with the integration strategy.
- Evaluate the system performance when operated or maintained by members of the target population in the intended environment to identify human factors causal information and its resulting resolution.

BP 08.07 Analyze evaluation results

Analyze results of evaluations and compare them to the needs and requirements to identify and quantify deficiencies, and recommend corrective and preventive actions.

Description
Evaluation activities are executed and the resulting data are collected according to established plans and procedures. The data resulting from test or evaluation are then analyzed against the defined evaluation criteria. Analysis reports are prepared to indicate whether or not requirements were met and, in the case of deficiencies, to assess the degree of success or failure, categorize the probable cause of failure, and support decisions to accept/decline products. The root cause of deficiencies should be determined and recommendations made for corrective and preventive actions. The results of peer reviews should be analyzed against established quality criteria and for defect trends.

Typical Work Products
- formal review minutes and action items
- peer review minutes and action items
- corrective action recommendations
- test incident reports
- test reports (analysis) and dispositions
- requirement change requests
- validation deficiency reports
- validation issues
- procedure change request
- evaluation anomaly root causes
- quick-look reports.

Notes
Evaluation analysis begins with a comparison of observed results with expected results (evaluation criteria) and proceeds through determination of the root cause of any deficiencies. Evaluation operations usually include a daily quick-look analysis effort for preliminary disposition of evaluation anomalies. Analysis reports or "as-run" method documentation may also indicate that evaluation anomalies are due to method problems, criteria problems, or an infrastructure problem. Typical results of quick-look dispositions are:
- test procedure problem
- test operator/maintainer error
- identified product deficiency
- referral for further analysis

Typical peer review data includes the 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. Analysis of peer review results includes checking for trends and root causes of errors.

The collection of verification performance data (such as: number of problem reports generated, amount of time required to conduct a test, number of regression tests, number of hours required to produce a document, estimate of the phase in which non-conformances were introduced into the product, etc.) is useful in improving the efficiency of evaluation.

Additional Practice Guidance

- Include in evaluation analyses an estimate of the project phase in which defects were introduced and opportunities to detect defects and deficiencies were missed.
- Analyze evaluation results for trends and interrelated anomalies.
- Involve all product stakeholders in the review of evaluation results and issues.

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PA 09: Deployment, Transition and Disposal

Process Area Summary

Purpose
The purpose of Deployment, Transition and Disposal is to place a product or service into an operational environment, transfer it to the customer/stakeholder and to the support organization, and deactivate and dispose of the replaced product and/or dispense with the service.

Major points addressed
This process area develops and implements a strategy for the Deployment, Transition and Disposal of products and/or suspension of services. It includes the design and coordination of plans and procedures for placement of a product or service into an operational and/or a support environment and bring it into operational use. It ensures an effective support capability is in place to manage, maintain and modify the supplied product or service. It further ensures the successful transfer of the product or service to the customer/stakeholder and the deactivation and disposition of the replaced capability.

Goals
1. Customer/stakeholder operation and support facilities are prepared to accept the delivery, placement and transition of the product or service into use. *(BP09.01, BP09.02)*
2. Customer/stakeholder operation and support personnel are prepared to accept delivery, placement and transition of the product or service into use. *(BP09.01,BP09.04, BP09.05)*
3. Customer/stakeholder operation and support organizations demonstrate their capacity to support the product or service upon assumption of responsibility. *(BP09.01, BP09.04, BP09.05).*
4. Continuity of operational performance is maintained. *(BP09.03, BP09.04, BP09.05)*
5. The replaced product or service is deactivated, disposed and/or dispensed of, as appropriate. *(BP09.06)*

Notes
- *Deployment* of a product or service involves planning and preparation activities associated with the placement of a product or service into an operation and support environment.
- *Transition* involves transfer of the product or service from the supplier to the customer/stakeholder operation and support organizations.
- *Deactivation* involves notification of users that the product or service is being replaced or withdrawn from operation.

- *Disposition* involves disassembly of the replaced item including the satisfaction of relevant health, safety and security regulations. If appropriate, it includes breaking down the replaced item into manageable elements to facilitate removal for reuse, recycling, reconditioning, overhaul or destruction.

Continuous communication between the supplier and the customer is essential for successful deployment and transition of the product or service.

Relationships between this PA and other PA's

This PA interacts with a number of other process areas. These include Requirements (PA 02), wherein the requirements are developed and managed that define the product or service to be placed and transitioned to the customer/stakeholder. Product and service features (e.g., specific materials) that affect transition, deployment, or disposal may be determined by Design (PA 03). Design Implementation (PA 06) requires this process area to ensure the support organization can modify, maintain, and support the new product or service. Requirements (PA 02) and Design (PA 03) provide interface information required for the placement and testing of the product or service in the customer's environment. Evaluation (PA 08) provides the basis for this PA to establish the environment for evaluation and acceptance of the product or service. Risk Management (PA 13) helps in managing risks as part of the strategy. Supplier Agreement Management (PA 12) provides process information for shipping, handling, storage, and delivery of the product or service. Integrated Teaming (PA 14) enables deployment, transition, and disposal practices to be accomplished in a team-based environment where stakeholders are engaged in applicable phases of activities. Training (PA 22) provides for long-term training of operational and support personnel who will place and transition the product or service. Configuration Management (PA 16) practices help in managing configurations during deployment, transition, and disposal. Operation and Support (PA 10) practices operate the deployed product or service. Issues relating to Transition, Deployment and Disposal may be resolved via requirement changes (PA 02).

Base practice list

BP 09.01 **Develop, deploy, and maintain a strategy for deployment, transition and disposal activities:** Develop a strategy for deployment, transition, and disposal and perform activities in accordance with the strategy.

BP 09.02 **Prepare facility and infrastructure environment:** Establish the facility and infrastructure environment to receive and operate the product or service.

BP 09.03 **Oversee configuration of product or service:** Verify fielded configuration items reflect the product or service baseline and manage change control.

BP 09.04 **Demonstrate support capability:** Demonstrate the ability of the customer/stakeholder support organization to maintain, modify and support the product or service.

BP 09.05 **Transition product or service:** Transfer the product or service to the customer/stakeholder operation and support organizations**.**

BP 09.06 Deactivate and dispose replaced product and/or dispense with service: Deactivate and dispose of the replaced product and/or dispense with the replaced service.

BP 09.01 Develop, deploy, and maintain a strategy for deployment, transition and disposal activities

Develop a strategy for deployment, transition, and disposal and perform activities in accordance with the strategy.

Description
The strategy covers the overall scope and objectives of deploying a product or service into an operational environment and transferring it to the customer/stakeholder and support organization. It includes deactivation and disposal of the product and/or discontinuation of the replaced service. The strategy includes design and coordination of plans and procedures for placement of a product or service and the identification and allocation of responsibilities, resource requirements, and schedule for the deployment, transition, and disposal effort. It includes identifying the risks involved and their mitigation. Plans and procedures are developed for sustaining continuity for performance of operations such as parallel operations during transition from the old to the new product or service.

Typical Work Products
- deployment strategy
- transition plan
- risk analysis
- risk mitigation plan
- disposal plan
- in-service review checklist

Notes
The strategy for successfully deploying and transitioning a product or service is closely integrated with an in-service checklist. The checklist provides a structured approach to ensuring that all actions required for the successful deployment, transition, and disposal of a product and/or discontinuation of a service are accomplished and the coordination and approval by those individuals in charge of the respective actions has been achieved. The decision to deploy a product or service to the customer's facility cannot be rendered without a completed and approved checklist.

BP 09.02 Prepare facility and infrastructure environment

Establish the facility and infrastructure environment to receive and operate the product or service.

Description
Prepare the site of operation in accordance with the installation requirements. This includes conducting site surveys and the development and coordination of site preparation plans in conjunction with the new product or service operation and support organizations. Site preparation includes the review and coordination of all relevant contractual documentation including contract and facility modernization schedules that impact the deployment of the product or service to the facility's operational and support environment.

Typical Work Products
- implementation and site activation documentation
- contract clarifications
- engineering change documents
- site surveys and engineering drawings
- site action item listing(s)
- facility/site preparation and implementation issues listing(s)
- product contract baseline schedules
- facility modernization schedules
- subsystems, support tools, and data source lists

Notes
Coordination is crucial between the supplier, the developing team, and the customer/ stakeholder organizations to ensure successful product or service deployment. This includes sharing information such as power requirements and availability at the customer's site to ensure consistency with standards, orders, contractual direction, and contract documentation.

Continual tracking of site survey action items and field issues is critical to ensure no impacts to schedules or costs from the time of product or service installation through the period of its deactivation and disposition.

BP 09.03 Oversee configuration of product or service

Verify fielded configuration items reflect the product or service baseline and manage change control.

Description
Develop a checklist of all items contained in the product or service that is being deployed to the facility and which will be transitioned to the customer/stakeholder operation and support organizations. The list is prepared by the supplier and coordinated with the customer during delivery and again during transition to the final customer or organization if the final customer is someone or some organization other than the initial recipient of the product or service. The items in this listing include, but are not limited to, system descriptive manuals, support software and hardware, corrective action and configuration management data, requirements management information and maintenance documentation. Develop a plan that describes how the product or service configuration will be transferred and how it will be managed after the transition.

Typical Work Products
- subsystems list
- support tools list
- data sources list
- user manuals list
- administration manuals list
- troubleshooting manuals list
- configuration management transition plan
- configuration management tool selection rationale

Notes
The developer/supplier transfers reliable information about defects and other quality-related issues (e.g., error logs, trouble reports, and reliability data) to the customer/stakeholder operation and support organizations to ensure the continuity of tracking activities.

The customer/stakeholder operation and support organizations learn enough about the configuration to be able to build, maintain and distribute the system without assistance from the supplier/developer.

The configuration management approach is adapted to the needs of a support and enhancement organization. The support organization evaluates the suitability of the configuration management tool to ensure its needs are satisfied.

The choice of a configuration management tool is documented and the configuration management transition plan contains a plan for tool migration and conversion.

BP 09.04 Demonstrate support capability

Demonstrate the ability of the customer/stakeholder support organization to maintain, modify and support the product or service.

Description
Transfer and tailor developer's processes to the support organization and demonstrate the customer's ability to maintain, modify, and support the facilities, equipment, and resources necessary for continuous operation of the product or service. These include the required hardware, software, personnel, plans, processes, procedures, and documentation. It includes the availability of and the capability to support an established configuration management system and an established requirements system. It includes software and firmware replication test and distribution capabilities. Training courses and training materials are developed and the customer/stakeholder/support organization personnel receive initial training to prepare them for the acceptance and transition of the new product or service. It also includes the identification, documentation, and resolution of the customer's issues, and the coordination of logistics (e.g., provisioning, sparing, etc.) and maintenance requirements associated with the deployment and transition of the product or service.

Typical Work Products
- training course material
- training plans
- customer/user guidance documentation
- operational data for contractor documentation
- change requests
- contract modifications
- provisioning/sparing documentation
- shipping and handling information
- packaging and storage information
- integration plans
- life cycle maintenance plans
- operational evaluation planning

Notes:
Training, logistics, and maintenance support capabilities are integrated support efforts requiring the participation of both the supplier or developer of the product or service and the customer during the deployment and transition of a product or service.

Due to the diverse nature of the parties involved, several practices such as logistics, maintenance, training, etc., are necessary for successful completion of this effort. These practices are also tied into Design Implementation (PA 06), Supplier Agreement Management (PA 12), and Training (PA 22) wherein the overall logistics, maintenance, and training are provided for the life cycle of the product or service.

BP 09.05 Transition product or service

Transfer the product or service to the customer/stakeholder operation and support organizations.

Description
Transfer the product or service to the customer/stakeholder operation and support organizations. This includes a demonstration and the ultimate transition of the facilities, equipment, appropriate resources, and responsibility for the product or service to the support organization. It also includes the transfer of the product or service support capability and management of the overall configuration of the system, including the requirements and traceability. It further involves the transfer of responsibility for the maintenance and support of related system/subsystem items, support tools, and data sources to the customer/stakeholder operation and support environment.

Typical Work Products
- metrics (measures)
- process status reports
- roles and responsibilities matrix
- transition plan
- completed in-service review checklist
- configuration management databases, tools, and procedures
- configuration item lists
- contract modifications
- configuration management status reports

Notes
If the supplier has reliable information about defects and other quality-related issues (e.g. error logs, trouble reports, reliability data), it is transferred to the customer with assurance that these tracking activities can be continued without interruption.

The demonstration of the support capability involves an independent organization, such as a Quality Assurance Group.

BP 09.06 Deactivate and dispose replaced product and/or dispense with service

Deactivate and dispose of the replaced product and/or dispense with the replaced service.

Description
Develop and document procedures required to deactivate and permanently remove/dispose of a product and/or dispense with the service. Notify user(s) of the product or service to be withdrawn. Deactivation or dismantling of the replaced item commences when the new product or service is considered to be operationally acceptable.

Dispose of the replaced product in accordance with appropriate disconnecting and disassembly instructions. Adhere to relevant health, safety, and security regulations. When appropriate, the product is broken down into manageable elements to facilitate its removal for reuse, recycling, reconditioning, overhaul, or destruction.

Typical Work Products
- deactivation plan
- disposal plan
- deactivation notice(s)
- termination notice(s)
- product or service change notice(s)
- facility restoration plans
- transfer, storage, and/or disposal documentation
- safety, security and environmental documentation

Notes
The procedures for deactivation and disposition are documented in various organizational orders, standards and regulations. Any unique actions required regarding the safety, security, and the environment are followed on a case-by-case basis depending on the replaced capability.

Replaced product disposition occurs in the following order of priority:
- Reassignment – Relocates the replaced capability to another location within the immediate organization.
- Transfer – Relocates the replaced capability to a location outside of the immediate organization.
- Donation – Provides the replaced capability to a donee without reimbursement.
- Sale – Exchanges the interest in ownership of the replaced capability for monetary reimbursement.
- Abandonment or destruction – Disposes of the replaced capability to a specified location after the procedures for reclaiming precious materials are followed.

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PA 10: Operation and Support

Process Area Summary

Purpose
The purpose of the Operation and Support process area is to operate the product, system, or service; support its users; monitor and sustain its performance; and take or initiate corrective action as required.

Major points addressed
Operation and support involves operating the product, system, or service in its operational environment to deliver needed customer services and providing operational support to those interacting with the service. Operational problems and performance levels are monitored, recorded, and analyzed in relation to established needs and requirements. Service levels are sustained by means of preventive and corrective maintenance activities, as required, and an adequate supply of replacement parts and materials is confirmed for this use. Corrective action is taken when warranted to correct random faults that can be corrected by replacement, or to correct failures attributed to human error. Problems that require permanent fixes, such as product or service corrections, improvements, or adaptations, are recorded and reported for corrective action. Temporary work-arounds are provided as appropriate. Operational support is available to provide assistance and consultation, and to handle user inquiries and requests.

Goals
1. The product, system, or service is operated and monitored. *(BP 10.01, BP 10.02)*
2. Methods are established and used to sustain required service levels and to detect the need for corrective action. *(BP 10.03, BP 10.04, BP 10.05)*
3. Operational support is provided and needed corrective actions are deployed. *(BP 10.06, BP 10.07)*

Notes
Operation and Support activities include preventive or corrective maintenance activities, but maintenance activities resulting in permanent product or service modifications due to a problem or the need for improvement or adaptation are carried out in other process areas (see below).

Relationships between this PA and other PAs
Operation and Support activities are managed using the practices of Project Management (PA 11) and, where appropriate, the principles and practices of Integrated Teaming (PA 14). If an operational problem results because customer or other stakeholder needs have changed, problems are not being resolved adequately, or capacity, service, or performance are not meeting expectations, Operation and Support may interact with activities of the Needs process area (PA 01) or the Innovation process area (PA 23). The Needs process area is also used in determining customer satisfaction or dissatisfaction to

address current and projected needs. These data may come from the Operation and Support process area. If requests for product or service corrections, adaptation, or improvements are reported (e.g. to provide omitted functions or features, or to develop enhancements), practices of the Requirements process area (PA 02) are used to analyze the impact of change requests. Approved modifications are developed and installed using the practices of Design (PA 03), Alternatives Analysis (PA 04), Design Implementation (PA 06), Integration (PA 07), Evaluation (PA 08), and Deployment, Transition, and Disposal (PA 09).

Required resources and replenishment levels for operation and support are determined using practices of Requirements (PA 02). Operational risks are identified and mitigated using the practices of Risk Management (PA 13). Operator training is provided through the Training process area (PA 22). Failure analysis data are provided to the Quality Assurance and Management process area (PA 15). Part of monitoring may include regular configuration audits as described in Configuration Management (PA 16). Practices of Measurement and Analysis (PA 18) are useful in collecting and analyzing data on capacity, service, performance, and operational problems. Results from evaluation of capacity, service, and performance may be reviewed in Integrated Enterprise Management (PA 00). The practices of Outsourcing (PA 05) are useful when assuring availability of parts and personnel.

Base practices list

BP 10.01 **Operate the system, product, or service**: Operate the system, product, or service in its intended environment and in the specified way.

BP 10.02 **Monitor and evaluate capacity, service, and performance:** Monitor and evaluate capacity, service, and performance of the system, product, or service.

BP 10.03 **Confirm availability of parts and personnel**: Confirm availability of required resources (personnel and parts) to ensure service levels can be sustained.

BP 10.04 **Perform preventive maintenance:** Perform preventive maintenance by replacing or servicing products/system elements prior to failure.

BP 10.05 **Analyze failures:** Perform failure identification actions when a non-compliance has occurred in the product or delivered service.

BP 10.06 **Take or initiate corrective action:** Take corrective action when appropriate (e.g., defective part, human error), or initiate corrective action for product or service modification.

BP 10.07 **Provide customer support**: Establish a service to answer customer and user questions and help resolve problems they encounter.

BP 10.01 Operate the system, product, or service

Operate the system, product, or service in its intended environment and in the specified way.

Description
Operate the system, product, or service to provide services needed by customers and other stakeholders. Operate according to instructions, procedures, and documentation provided.

Typical Work Products
- services provided
- services delivered

Notes
None.

BP 10.02 Monitor and evaluate capacity, service, and performance

Monitor and evaluate capacity, service, and performance of the system, product, or service.

Description
Monitor operation to confirm that performance is within acceptable parameters. Ascertain and confirm that hardware elements, as applicable, will not exceed their useful life. Confirm that the effects on operating personnel of operating the system, product, or service do not exceed permissible or acceptable bounds for factors such as stress and fatigue. Monitor to assure awareness of potential problems that might impact service levels. Record capacity, service levels, capability, and performance data.

Typical Work Products
- service levels
- capacity
- performance levels
- identification and documentation of effects on operators
- hardware replacement or repair notices
- operational problem reports
- product supportability projections
- product compatibility testing reports
- cost-benefit analyses of support alternatives
- regular operational reports
- configuration audits

Notes
Monitor capacity, service, capability, configuration, and performance on a regular basis.

The monitoring function should also include collecting COTS product support and end-of-life/end-of-service information from the respective product vendors (associated with Outsourcing (PA 05)) to project and assess product availability, spares levels, vendor support, compatibility of replacement products, alternative support options, system impacts if not available etc. Evaluation includes establishing a system-level testbed capability to maintain the system hardware and software components and to test replacement products for upward/downward compatibility with the existing system. Evaluation also includes taking test and spares availability information and trading off (i.e., cost, benefit, risk) product/system supportability alternatives (e.g., life of type buy, extended warranty, purchasing data rights, technology refreshment, redesign, etc.). This will determine if the solution is a simple reprocurement action for compatible replacement parts or a system change that feeds back into Needs (PA 01).

Establish supportability data collection system with product vendors.

BP 10.03 Confirm availability of parts and personnel

Confirm availability of resources required (personnel, parts) to assure service levels can be sustained.

Description
Confirm that logistics actions satisfy the required replenishment levels so that stored system elements meet repair rates and planned schedules. Monitor the availability of stocked spares, the ability to procure additional/compatible spares, their transportation and their continued integrity during storage. Acquire, train and accredit, as necessary, personnel to maintain appropriate numbers and skills for operators, technicians, and service providers.

Typical Work Products
- logistics reports
- planned and actual levels of replacement parts
- planned and actual numbers of skilled operators or service providers
- notices of potential shortages or excesses

Notes
The monitoring of spares availability with COTS-based systems includes identifying what is available in the commercial market for either exact replacement spares or form, fit, function (F3) compatible replacements. This activity includes market investigation of alternative sources (other vendors) of possible suitable replacement products to be tested.

BP 10.04 Perform preventive maintenance

Perform preventive maintenance by replacing or servicing products/system elements prior to failure.

Description
Replace or service elements prior to failure according to planned schedules and maintenance procedures in order to eliminate causes of potential problems and prevent their occurrence.

Typical Work Products
- replaced elements
- serviced elements
- preventive maintenance records

Notes
Preventive maintenance is performed to maintain required service levels with minimal interruption. Identify potential problems and their causes, determine preventive actions needed, implement the actions as required, and record results.

BP 10.05 Analyze failures

Perform failure identification actions when a non-compliance has occurred in the product or delivered service.

Description
Analyze failures to determine their cause so that appropriate corrective action can be taken or initiated. Failures may be detected through monitoring or may be identified by operators or customers via problem reports.

Typical Work Products
- failure analysis report

Notes
Causes of failures may be determined to be random or systematically occurring. Causes may be linked to human error or malfunctioning units, or they may be due to changing needs or requirements.

BP 10.06 Take or initiate corrective action

Take corrective action when appropriate (e.g. defective part, human error), or initiate corrective action for product or service modification.

Description
Take corrective action if failure analysis has determined that the failing or potential failing can be corrected by replacement of a part or procurement of a compatible replacement part. When human error contributed to the failure, introduce remedial changes to procedures, the environment, or training as appropriate.

When failings are due to changed needs or requirements, confirm with customers and stakeholders whether to change the product or service or to tolerate diminished service levels. Submit problem reports if permanent corrections are needed. If a reported problem has a temporary work-around before a permanent solution can be provided, document and provide this information as appropriate. Review priorities for problem resolution with the customers and stakeholders.

Typical Work Products
- problem reports
- trouble reports
- remedial changes
- records of corrective action taken
- temporary work-arounds
- temporary solutions
- operational instructions
- problem trends
- corrective action assignment
- tracking system

Notes
Problem reports or requests for product or service modification are inputs to the Requirements process area (see PA 02).

Maintain a history of problem reports, corrective actions, and trends to inform operation, maintenance, or redesign actions and other projects that are creating or utilizing similar products, systems, system elements, or services.

Track corrective actions and notify affected parties.

BP 10.07 Provide customer support.

Establish a service to answer customer and user questions and help resolve problems they encounter.

Description
Establish a service so that assistance and consultation are provided to customers, stakeholders, and users of the product or service. Ensure a mechanism is in place to monitor, record, and respond to all requests and problems related to the operation of the system, product or service, forwarding requests as appropriate.

Typical Work Products
- help desk
- procedures
- change requests
- problem reports
- user or customer requests for service
- responses to user requests
- status of user requests
- user training
- customer assistance
- problem analysis
- trend report
- support guide for customers
- tracking system

Notes
Inform customers and users of the status and disposition of problem reports and requests.

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PA 11: Project Management

Process Area Summary

Purpose
The purpose of Project Management is to ensure the project achieves its objectives, by planning, directing, tracking, and controlling the activities necessary for development and delivery of required products and services.

Major points addressed
The Project Management process area involves developing project and technical plans and maintaining them throughout the project life cycle. Estimates are established and maintained regarding cost, schedule, size of work products, and critical technical parameters. Commitments to project objectives and plans are established and maintained throughout the project. Project participants and stakeholders are identified and organized to meet project objectives.

As the project is executed, project and technical performance are monitored and tracked in accordance with the plan. Corrective actions are taken as needed to ensure the project will meet its objectives.

Goals
1. Project plans are established, maintained, and executed to provide required products and services that reflect customer and stakeholder needs. *(BP 11.04, BP 11.05, BP 11.06, BP 11.08, BP 11.09)*
2. Estimates of the project's planning parameters are established and maintained to support resource estimates. *(BP 11.01, BP 11.02, BP 11.03)*
3. Commitments related to the project are established and maintained. *(BP 11.07)*
4. Progress of the project is evaluated against its plans. *(BP 11.10, BP 11.11)*
5. Corrective actions are taken when appropriate and managed to closure. *(BP 11.12)*

Notes
Project management processes are used to establish and evolve project plans, to assess actual achievement and progress against the plans, and to control execution of the project to successful conclusion. The resources applied to project management should be scaled according to the size and complexity of the project. Stakeholders should be involved in project planning to ensure every participant understands what resources are required and commits to providing them when needed. Examples of small projects are typically found in research or infrastructure efforts. The determination and continuous adjustment of the appropriate effort and scope for management of a project is an appropriate activity of Project Management.

Coordination and commitment among affected groups and individuals (stakeholders) is critical to successful development and execution of plans. The detail and formality with which Project Management processes are applied should be adjusted according to the

size, criticality, complexity, and risk of projects. Some level of disciplined project management is appropriate for the smallest of projects. Project Management processes are applicable to all manner of projects, including planning, new product or service design and development, production, operations, maintenance, product or services evaluation, and support. Project Management applies to managing a business unit or a service organization.

The project manager is ultimately responsible to the customer.

Relationships between this PA and other PAs

Project Management establishes and maintains the schedules, resources, and integration of the activities of all process areas. Project Management gathers information and provides information to the processes engaged in providing the products and services through all life cycle phases.

Projects are chartered and supported by Integrated Enterprise Management (PA 00). The customers and stakeholders for the project, and their expectations, are identified in Needs (PA 01). Project plans and schedules depend critically on project requirements from the Requirements process area (PA 02). The integrity of the requirements and the ongoing consistency between requirements and project plans depend on close coordination of Project Management and the Requirements process area activities.

The activities of Project Management interface with Outsourcing (PA 05) and Supplier Agreement Management (PA 12) to plan and monitor acquisition of products, services, skills, or other solution components from external sources. Configuration Management (PA 16) is essential to provide Project Management with configuration control and status of the evolving products or services. Project Management coordinates with Training (PA 22) regarding project training needs and individual training plans. Quality Assurance and Management (PA 15) feeds process and product quality information and nonconformance issues to Project Management. Measurement and Analysis (PA 18) provides measurement data in support of project monitoring and tracking and Quality Assurance and Management. Integrated Teaming (PA 14) supports Project Management in establishing and supporting teams to achieve the level of coordination and communication among stakeholders and the integration of effort necessary for timely, effective execution of the project. The practices of Risk Management (PA 13) are crucial in managing risk areas that could adversely affect planned performance.

Base practice list

BP 11.01 **Define project objectives, scope, and outputs:** Define project objectives, scope, and the work products and services that are to be provided by the project.

BP 11.02 **Define the activities and life-cycle approach:** Define the activities needed to achieve project outputs and the life-cycle approach that will be used.

BP 11.03 **Estimate planning parameters**: Estimate and document the work product and task planning parameters that provide a basis for resource estimates.

BP 11.04 **Estimate project resource requirements:** Estimate the project effort, cost, and other resource requirements.

BP 11.05 **Establish schedules:** Develop management and technical schedules for the project.

BP 11.06 **Establish and maintain plans:** Establish and maintain a complete set of plans for providing the products and services throughout the project life cycle.

BP 11.07 **Establish commitment:** Establish and maintain commitment of affected groups and individuals to project objectives and plans, and commitment of resources as identified in the plan.

BP 11.08 **Organize to meet project objectives:** Identify individuals or teams that will be assigned the resources and responsibilities for meeting project objectives.

BP 11.09 **Direct the project:** Communicate project plans, direction, corrective actions, and status, and coordinate project activities.

BP 11.10 **Monitor Project Performance:** Monitor and track project activities and results against plans.

BP 11.11 **Review and Analyze Project Performance:** Conduct formal and informal reviews of project performance and analyze variances from plans.

BP 11.12 **Take Corrective Action:** Take corrective actions to address problems.

BP 11.01 Define project objectives, scope, and outputs

Define project objectives, scope, and the work products and services that are to be provided by the project.

Description
Determine project objectives and measures that will be used to evaluate performance. Identify project constraints, and the scope of the project endeavor. Confirm the customers for the products and services that the project will deliver. Identify and define the products and services that will constitute the deliverable outputs of the project. Work product and service definition includes the characteristics and requirements of work products and the criteria by which they will be evaluated. Work product requirements flow from or trace to the product and service requirements established as inputs to the project (i.e., outputs of Requirements (PA 02)). A project may have been initiated based on a statement of need, and more precise project requirements may be a project deliverable. Identify interim (non-deliverable) work products and their requirements.

Typical Work Products
- project objectives, scope, and constraints
- project performance measures
- deliverables
- work products, and services
- characteristics, requirements, and evaluation criteria for products and services
  - non-deliverable work products and their requirements (deliverables are inputs)
- lists of project information items and categories of information to be managed
- list of customers
- key technical parameters

Notes
Examples and guides for work product definition (e.g., requirement and design document templates) can be found in industry standards on engineering and project management.

Additional Practice Guidance
- Review customer contracts and statements of work to identify work products and activities.
- Correlate work products and deliverables with identified activities.
- Review orders, policies, and regulations.
- Identify the project objectives and constraints in terms of quality, cost, time and stakeholder satisfaction. Identify each objective with a level of detail that permits selection, tailoring, and implementation of the appropriate processes and activities.
- Define the project scope based on the stages in the whole system life cycle. Confirm that the project includes all the relevant activities required to satisfy enterprise decision criteria and complete the project successfully.

BP 11.02 Define the activities and life-cycle approach

Define the activities needed to achieve project outputs, and the life-cycle approach that will be used.

Description
This practice identifies the activities that will be carried out. Project activities include management, technical, and support activities that form the basis for providing the required products or services. Management activities include activities for continual assessment of plan execution and application of appropriate corrective actions and re-planning. Support activities may pertain to configuration management, information management, quality assurance, training, measurement, or establishment of facilities. Because of the potentially large number of activities that need to be planned, an organized and disciplined approach should be followed for activity identification.

This practice also structures those activities into life-cycle phases that will be used by the project to provide the required products or services. Considerations in selecting the project life cycle are whether the product or service is precedented (performed before), the degree of risk (technical, cost, and schedule), and the project size and duration. Determination of the life-cycle approach considers management issues such as in-house development or outsourcing (PA 05), and the use of non-developmental items. Typical life cycle models include waterfall, evolutionary spiral, and incremental.

The documented management, technical, and support activities provide the basis for plans for the project and for a schedule of project activities.

Typical Work Products
- work breakdown structure
- lists of identified activities
- activity descriptions
- product and service evaluation 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
- selected project life cycle model
- selected technical process
- project phases
- project commitment decision points
- criteria for continuing into subsequent phases
- cycles and phases of operation
- maintenance cycles

Notes
Sources for identification of project activities include work product hierarchies and activity lists from other projects. Historical data from similar projects, where available, can be used as a reference in developing the list of activities in order to gain confidence

that the list is complete. Methods such as the Delphi method, whereby peer-level experts are used to add activities and refine the list may also be helpful.

The project's life-cycle phases should include planned periods for evaluation and decision making. These periods provide for logical decision points that allow relatively efficient project course corrections and appropriate decision and analysis regarding significant commitment of future resources. The technical plan developed in Establish and Maintain Plans (BP 11.07) will include process activities, inputs, outputs, sequences, and quality measures that are tied to the increments in the identified lifecycle model.

Additional Practice Guidance

- Review historical records for similar projects to aid in identifying all the required activities.
- Consult with experts to identify activities.
- Conduct peer reviews and brainstorming sessions to identify activities.
- Compare the list of project activities with the requirements to aid in maintaining consistency between plans and requirements.
- Evaluate alternative life-cycle models against established selection criteria.
- Establish decision criteria for continuing into subsequent phases.
- Develop alternative courses of action for subsequent phases.

BP 11.03 Estimate planning parameters

Estimate and document the work product and task planning parameters that provide a basis for resource estimates.

Description
Determination of justifiable planning parameters (e.g., size, scope, and complexity) is a prerequisite for estimating the project effort hours, cost, and schedule (BP 11.04). The project's scope and size is dependent on the technical approach and can be estimated by decomposing the conceptual product or service into component elements that are similar to those of other projects. Size estimates can then be adjusted for factors such as differences in complexity or other parameters throughout the life cycle of the project.

Historical sources and models calibrated to historical experiences often provide information for initial size estimates. Initial estimates can be refined as more information on the current project becomes available. Planning parameters should be documented and their validity tracked so they can be refined to support re-planning or planning for other projects.

Typical Work Products
- required skill level of staff
- maximum number of aircraft per hour per route
- average/maximum number of service requests per week (if not specified by customer)
- average time to respond to a service request
- average/maximum number of change requests per week (if not specified by customer)
- average and maximum number of hospital patients per week
- number of functions, inputs and outputs, data volume
- number and frequency of user interactions
- number and complexity of interfaces
- number of technical risk items
- number of source lines of code or function points
- computer resources
- number of cards of electronics
- number of cubic yards of material to be moved
- relative complexity of work products and tasks
- planning parameter rationale

Notes
A considerable amount of project data, including scope, requirements, and material items must be identified and evaluated prior to estimating cost, schedule, and material needs. Checklists and historical data from other projects can be used to identify cost items that may otherwise be overlooked. Variance reports and lessons-learned documents are typically good sources of this type of information. Planning parameters are dependent on the technical approach, i.e., the top-level strategy for development of the products. Determination of the technical approach may require a high-level iteration of the

architecture and design process for the product or service. In the case of products it may include 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. In the case of services, the technical approach may include such factors as which service element(s) will interact with customers, how customer service issues will be processed and resolved, and how premium services will be priced and marketed.

Estimates are incorporated into the plans and are maintained throughout the full life cycle.

Additional Practice Guidance

- Base planning parameters on the identified tasks, products, and services and on the technical approach.
- Use established historical data or models to determine the planning parameters.
- Document the basis and rationale for planning parameters for use in maintaining plans.

BP 11.04 Estimate project resource requirements

Estimate the project effort, cost, and other resource requirements.

Description
Estimates of effort hours and cost are determined by applying labor and cost estimation methods to the planning parameters and the identified tasks, work products, and services with consideration to schedule and other constraints. Historical parameters or cost models calibrated to historical data are employed to estimate labor costs based on job complexity, tools, available skills and experience, schedules, and direct and overhead rates for similar projects. Estimation parameters and models should be based on measurement data and available from an organizational repository. Other resource requirements, including special skills and knowledge, are determined by reviewing the project requirements and the technical approach.

A detailed estimate of project costs, including life-cycle support costs is essential to good project management. Estimates of project costs are made by determining the labor costs, material costs, and subcontractor costs expected for the project's planned activities and the identified scope of the system to be built. Both direct costs and indirect costs (such as the cost of infrastructure, work environment, tools, training, special test and support items) are included. Appropriate reserves are established, based on identified risks.

Estimates are independently reviewed.

Typical Work Products
- total labor hours by skill level and schedule
- total labor cost by skill level and schedule
- cost of material by item, vendor, and schedule
- cost of subcontracts by vendor and schedule
- identification of skills and knowledge not commonly available
- cost of acquisition
- cost of tools
- cost of training
- life cycle support costs
- supporting rationale

Notes
A considerable amount of project data such as scope, schedule, planning parameters, and material items must be collected prior to estimating costs. Checklists and historical data from other projects can be used to identify cost items that may otherwise be overlooked. Variance reports and lessons-learned documents are typically good sources of this type of information. Estimates may be derived from historical sources, calibrated models, Delphi methods, or other ways.
Estimates are incorporated into the plans and are maintained throughout the full life cycle.

Additional Practice Guidance

- Use checklists and lessons learned from other programs to assure that all costs are determined.
- Include supporting infrastructure needs when estimating schedule and cost.
- Maintain a repository of costing models and historical data to support re-planning and planning for future projects.
- 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.
- Examine the project schedule and identify the types of resources required at each point in time.
- List resources that are not easily obtainable. Cross check and augment this list by identifying skills that are required to synthesize the system and work products.

BP 11.05 Establish schedules

Develop management and technical schedules for the project.

Description
Coordinated schedules, at an appropriate level of detail, are needed for all project activities including work product and service development, formal and informal management and technical evaluations, support functions, and acquisition of materials, skills, knowledge, tools, and facilities. Schedules are based on verifiable effort models or data for identified tasks, and must allow for task interdependencies and the availability of procured items. Schedules should include slack time appropriate for identified risks. All affected parties must review and commit to schedules.

Typical Work Products
- activity charts
- PERT diagrams
- project schedules
- milestone charts
- technical schedules
- critical paths
- schedule dependencies

Notes
The determination of schedules interacts strongly with the other project management practices. Scheduled activities are organized within the lifecycle phases and must account for all identified activities and work products of the project master plan and supporting plans. Management of schedule item dependencies and reserves (e.g., slack time) are coordinated with identified risks and risk mitigation activities.

Milestones for contractor product and service delivery often merit special attention due to the increased risk (factors outside direct control of the project). Schedule events should be included for monitoring the status of externally acquired products and services. For example, if the project is critically dependent on training services (e.g., training on a specific type of equipment to support its maintenance service) it may be advisable to add milestones to check the status of the training availability and/or its procurement status.

On complex projects it may be advantageous to define near-term activities more precisely than activities that start later in the project ("rolling wave approach"). Schedules should be evaluated against labor profiles in order to level peaks and valleys in labor needs.

Additional Practice Guidance
- Identify events and accomplishments that affect achievement of schedule milestones.
- Schedule reviews with a frequency that supports effective and efficient corrective action.
- Schedule slack time to allow for corrective action prior to the start of subsequent tasks.

- Identify and evaluate risks associated with meeting schedule milestones.

BP 11.06 Establish and maintain plans

Establish and maintain a complete set of plans for providing the products and services throughout the project life cycle.

Description
Establishing and maintaining a complete set of plans that define the project, management of the project, and interaction with internal and external organizations is critical to project success. The project plans are policy-driven, documented descriptions of all the resources, management, and technical activities, supporting and infrastructure activities, responsibilities and schedules needed to meet the project's product, service, and organizational objectives. They include commitment and coordination among project staff and with other affected individuals and groups. Initial plans and updates are provided with the timeliness needed to meet project and customer objectives. Provisions for verification of work products, services, process compliance, and corrective actions are included. Plans are updated and maintained in concert with the need for corrective actions as determined via the monitor and control practices.

Supporting plans are needed for a broad range of support functions that are necessary for successful delivery of products and services to the customer. These include definition of the structure of authority and responsibility; acquisition of materials, goods, and enabling services (e.g., plans for solicitation, supplier selection, acceptance, contract administration and contract closure); identification and management of project information (including its security, archival, and availability to project staff), provision for development facilities and tools; and definition of project quality activities. Project support plans should be integrated by defining their interfaces and work product dependencies. Planning for infrastructure and support includes planning the activities to develop these supporting plans.

Typical Work Products
- project management plan
- updates to plans
- criteria for plan revisions
- project memoranda (for minor plan changes)
- plan content requirements
- project resources
- risks
- project organization and assignments
- project schedule
- selected systems engineering process for the project
- subordinate supporting plans
  - configuration management and information management
  - quality management
  - training plans (project-unique)
  - risk management

- security and safety
- acquisition of products and services, reuse and COTS
- budgeting/funding increments
- acquisition of skill and knowledge
- facilities and support environment (tools, communication equipment, computers)
- product and service evaluations
- monitoring, tracking, and review
- on-going process improvement

Notes
Planning of the technical activities for the full life cycle is identified in the project plans. Engineering activities should be integrated into technical planning for the entire project. These activities include the planning of engineering support facilities and tools.

Technical management plans typically include:
- plans for developing the products and services
- plans for interacting with other organizations (e.g., subcontractors) performing the technical effort

Plans should include key technical parameters that can be traced over the life of the project and that will serve as in-progress indicators for meeting the technical objectives. Key technical parameters can be identified through interaction with the customer, customer requirements, market research, prototypes, identified risks, or historical experience on similar projects. Each technical parameter to be tracked should have a threshold or tolerance beyond which some corrective action would be expected. Key technical parameters should have pre-planned assessments scheduled at useful points in the project schedule.

Decisions will need to be made as to whether to include infrastructure and support planning in the project plan or in subordinate plans, based on the size and complexity of the project. Acknowledged experts, other project plans, organization policies and procedures, and lessons learned are sources for infrastructure and support planning.

The responsibility for project-unique skill and knowledge is shared by project management and organizational training functions. Project management is responsible for identifying project skill and knowledge needs, individual training plans for project staff, coordination of training with the organizational training function, and coordination of the acquisition of external expertise with Contracts Management.

Additional Practice Guidance
- Involve appropriate stakeholders in developing project plans.
- Establish methods for rapid amendments to plans (e.g., between plan updates).
- Establish methods for providing operation detail for plans, such as project directives.
- Include performance thresholds for corrective actions.
- Provide a mechanism to trigger plan updates when requirements change.

- Base the need for infrastructure and support plans on project size and complexity.
- Identify the infrastructure and support plan stakeholders.
- Coordinate and integrate the various infrastructure and support plans.

BP 11.07 Establish Commitment

Establish and maintain commitment of affected groups and individuals to project objectives and plans, and commitment of resources as identified in the plan.

Description
This practice provides for negotiation and obtaining commitment of project staff and of the affected groups and individuals that interface with the project. Commitment of individuals and groups is based a common understanding of the project objectives (shared vision) and the activities and resources needed to achieve the objectives. Establishing commitment includes negotiating project resources, scope, and requirements with management and customers in order to secure the commitment of resources identified in the plan. Commitment is maintained throughout the project duration.

Assign requirements and responsibilities to individuals and teams. Obtain commitment from project individuals and teams and from external entities to their assigned requirements, responsibilities and resources. Commitment of individuals and groups is based a common understanding of the project objectives (shared vision) and the activities and resources needed to achieve the objectives. Establishing commitment includes negotiating project resources, scope and requirements with management and customers in order to secure the commitment of resources identified in the plan. Commitment is maintained throughout the project duration.

The objective of project plan reviews is to ensure a bottom-up, common understanding of the process, resources, schedule, and information requirements by affected groups and individuals (stakeholders) throughout the project. Inputs on the project plan are solicited from all affected organizational elements and project staff. Whenever possible, these inputs are incorporated to build team ownership of the plans. If an input is rejected or modified, feedback is provided to the originator. Interim and completed project plans are distributed for review. A commitment to the project plans is obtained from all groups comprising the project team.

Project interfaces include any interface with organizations and individuals that are necessary to successful project execution, whether they are inside or outside the project group. Types of interaction include information exchange, tasking, and deliveries. Methods and processes (including controls) for interaction are established as appropriate for the parties that are interacting.

Typical Work Products
- documented commitment from individuals, teams, organizational elements, suppliers and customers
- committed resources
- allocated funds
- defined processes for project interfaces
- interface issues between disciplines/groups
- memoranda of understanding

- risks
- project plan inputs
- project plan comments
- project plan issues and resolutions

Notes
Affected groups and individuals typically include:
- software engineering
- hardware engineering
- manufacturing
- management
- customers
- users
- partners
- subcontractors

Establishing the commitment of individuals to their assigned responsibilities requires that the individual have a full understanding of the required tasks and a justifiable confidence that the task(s) can be performed with the assigned resources. Commitments lacking such understanding and confidence pose a risk to the project. In general achieving individual commitment requires a negotiation between project management and the individual. Negotiation may result in identifying new approaches to performing tasks, new tools, additional training, requirement changes, or changes in budget or schedule.

An example of achieving the commitment of groups to plans involves structured reviews. Identify questions that each group should answer as part of their review for commitment. The questions may be different for different groups. Communicate to the groups how the review will be conducted. Provide the technical management plans to the groups and meet with them at a pre-arranged time to discuss their comments. Produce a list of issues from the reviewers' comments and work on each issue until it is resolved.

Additional Practice Guidance
- Identify the project plan stakeholders and affected groups and organizations.
- Solicit plan inputs and review comments.
- Negotiate commitment and responsibility with project staff.
- Reconcile available resources with the scope of work.

BP 11.08 Organize to meet project objectives.

Identify individuals or teams that will be assigned the resources and responsibilities for meeting project objectives.

Description
Establish a project organizational structure appropriate to the project activities and work products. Establish and use integrated teams for groups of activities or work products that are interdependent or that would benefit from the characteristics of integrated teams. Establish an appropriate number and size of teams based on consideration of project characteristics, work product dependencies and an efficient balance between inter- and intra-team coordination. Define the scope of work for individuals and teams and confirm that the number of teams and work scope is viable through a preliminary assignment of requirements and responsibilities and analysis of workloads and overall work coverage. Identify stakeholders appropriate for participation in project activities, and maintain and communicate stakeholder lists. Consider the project activities that would benefit from stakeholder participation and identify stakeholders according to their relevance to the activities.

Typical Work Products
- project organizational structure
- integrated team identifications
- integrated team membership
- inter-team coordination procedures
- team charters
- team and individual objectives, assignments, and resources
- lists of stakeholders by activity
- stakeholder contact information
- stakeholder availability and constraints
- stakeholder information access mechanisms and procedures
- review and meeting distribution lists
- stakeholder inputs

Notes
Project organization around integrated teams has been found to work well in project situations with the following characteristics:
- Project results are organized and managed around work products, as opposed to activities (team focus on work products).
- The project has technology risks or issues whose resolution would benefit from focused diversity of inputs and team synergy.
- Work products assigned to teams have a complex and highly interdependent structure that would benefit from the tight coordination provided by teams.
- Labor and schedule resources are available to support the slightly higher overhead involved in intra-team coordination and decision making.

In some cases (typically the inverse of the above) individual assignments may be more effective. (For example, a work product that can be sub-divided into relatively independent parts and handled by highly skilled individuals, where effort and schedule are highly constrained.) The integrated team structure can encompass the whole project with a network of sub-teams, coordination teams, and individuals. The Integrated Teaming process area (PA 14) provides detailed practices on establishing and supporting integrated teams.

Candidates for stakeholders include, in addition to project staff, higher levels of management, customers, users, customer experts, law enforcement, and policy-makers. In the FAA context, stakeholder candidates include passengers, pilots, crew, controllers, management, airline staff, site municipal officials, lawmakers, news media, and the general public. Refer to the practices of the Needs process area (PA 01) regarding identification of stakeholders.

Additional Practice Guidance

- Establish an appropriate number of coordination teams to coordinate the efforts and interfaces among teams.
- Involve appropriate stakeholders in determining corrective actions.

BP 11.09 Direct the project

Communicate project plans, direction, corrective actions, and status, and coordinate project activities.

Description
Provide day-to-day direction for the project including distribution of project plans and addenda, authorization to commence work on project activities, direction to suspend or terminate activities, resolution of questions and issues, communication of project status and meetings, coordination among tasks and individuals, and ad-hoc tasking as required. Maintain informal participation and contact with project staff and stakeholders to keep informed on progress, issues, and staff morale.

Schedule project activities, such as reviews, with consideration of stakeholder commitments and constraints. Provide stakeholders with appropriate access to project information. Obtain inputs from stakeholders on requirements, issues, and work product and schedule dependencies.

Provide for communication and coordination among individuals and teams.

Typical Work Products
- written and verbal tasking
- project memoranda
- work authorizations
- stop work orders
- project status
- project meetings
- question and issue resolution

Notes
There are many resources available on project management including training courses, publications, best practices, tools, and techniques. Successful project managers use a variety of tools and techniques for effective communication and coordination with project staff. One highly touted method is called “management by wandering around” or MBA.

Additional Practice Guidance
- Maintain an open door policy that encourages project staff to bring questions, issues and improvement opportunities to project management.

BP 11.10 Monitor project performance

Monitor and track project activities and results against plans.

Description
Monitor and track management and technical progress through all phases of the project. Include tracking of planning parameters, technical performance, budget, schedule, and resources against established project plans. Progress is determined by measuring the performance and the variance between planned performance and actual performance at predetermined levels of detail. Monitor and track performance measures established for the project.

Monitoring provides visibility of progress, and insight into the risks of the project. Visibility encourages timely corrective action when performance deviates from plans. When issues or concerns arise performance parameters are tracked at finer resolution. Project monitoring includes establishing and using methods to collect and manage issues.

Typical Work Products
- cost and schedule performance
- cost and schedule variance
- defect densities and trends
- technical performance measures
- technical parameter trend data
- resource usage data
- change requests for the project management plan

Notes
Monitoring management performance includes measuring the variance to plan of cost and schedule for designated management activities (e.g., reviews, plan updates). Monitoring technical performance involves measuring the cost and schedule variances of technical effort, as well as selected technical parameters (e.g., number of transactions supported, sensor accuracy, and product or service availability) and defects (e.g., errors per thousand lines of code, number of evaluation non-conformities, volume of rework, etc.).

When variances are identified that approach or exceed the pre-determined levels, a finer granularity of monitoring may be needed to track specific performance factors.

Earned value is a typical method used to determine cost and schedule variance. Earned value is used with other indicators to provide more accurate insight into issues and problem areas.

Additional Practice Guidance

- Establish guidelines and thresholds for reporting variances.
- Evaluate and adjust the frequency of measurements in order to detect variances before they become significant risks to project success.
- Correlate and document actual performance and planning parameters for use in re-planning and for future projects (historical data).
- Document lessons learned for use in ongoing project management and planning and managing future projects.

BP 11.11 Review and analyze project performance

Conduct formal and informal reviews of project management and technical performance and analyze variance from plans.

Description
Performance measurement data obtained from monitoring and tracking activities is reviewed and analyzed to identify risks, analyze variances to determine if corrective action is needed, and to determine if measurement (tracking) frequency and variance reporting thresholds need to be revised. The need for corrective action is based on comparing variances to pre-determined action thresholds. Performance data, variances, exceeded action thresholds, and other issues are elevated to appropriate levels of management for determination of corrective actions. Progress in meeting technical objectives is monitored at appropriate levels ranging from peer reviews to formal design reviews. Risk management results, including risk assessments and decisions on mitigation alternatives, are reviewed to influence or validate risk management strategy. Project performance is reviewed with customers to assure agreements are being satisfied.

Typical Work Products
- program management reviews and agendas
- minutes/slides
- lists of performance issues needing corrective action
- risks discovered in perform review and analysis
- "top ten issues"
- formal reviews (system requirements, design, and subsequent reviews, preliminary and critical design reviews, and test readiness reviews)
- management reviews
- quality assurance reviews and audits (functional configuration audit, preliminary configuration audit, process audits, product audits)
- technical reviews
- status reports
- action item list

Notes
Corrective action thresholds are established and documented in project plans. Thresholds may need to be revised as the project progresses, due to risks or other factors. Variances that are close to action thresholds or those that can be extrapolated to cross action thresholds (e.g., through trend analysis) in the future are candidates for finer resolution tracking.

Reviews are scheduled with agendas provided. Artifacts of the meeting are kept and action items recorded and tracked to closure. Reviews include all affected groups and individuals including, e.g., senior management, project management, task management, system engineering (hardware and software), test, maintenance, operations, quality assurance, end user, customer, subcontractors, external system representatives, and the business office.

Examples of reviewing performance include:

- Meetings of the stakeholders of the project to present analyses of performance and suggested corrective actions
- Status reports which document a particular issue or occurrence (technical meeting)
- Analysis of project management indicators
- Review of contractor prepared management reports

Additional Practice Guidance

- Maintain records of variances, defects, and issues and evaluate for trends.
- Extrapolate variances as a method of identifying risks and potential impacts to budget and schedules.
- Establish an environment that encourages early reporting of problems (before they become larger problems).
- Use the results of early validation to support tracking and oversight of project performance.

BP 11.12 Take corrective action

Take corrective actions to address problems.

Description
When problems or potential problems are identified, corrective actions are taken commensurate with the nature and magnitude of the problem. These corrective actions may take the form, for example, of reallocating resources, changing methods and procedures, or increasing adherence to the existing plans. When the complexity of the problem warrants, formal decision analysis may be needed to identify a number of alternative corrective actions and selection of the appropriate alternative based on coordinated and approved criteria. Project plans are revised to reflect the corrective actions. Corrective actions are tracked to closure.

Typical Work Products
- resource reallocations
- changes to methods and procedures
- change orders
- action items
- requirement changes
- schedule changes
- changes in project scope
- project plan revisions
- decision to terminate the project

Notes
This base practice covers whatever actions are needed to prevent anticipated problems or to correct the problems discovered. Corrective actions may involve reassignment of personnel, project re-organization, acquisition of new tools or skills, and budget and schedule adjustments. The possible actions taken under this base practice are varied and numerous. Lessons learned should be reviewed to identify types of corrective actions that are usually successful and those that are not. For example, adding personnel to a late project is usually not an effective corrective action.

Additional Practice Guidance
- Involve appropriate stakeholders in determining corrective actions.
- Evaluate risks associated with alternative corrective actions.
- Define new metrics, data gathering, and analysis where information provided fails to effectively detect non-compliance, faults, and adverse trends.

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PA 12: Supplier Agreement Management

Process Area Summary

Purpose
The purpose of Supplier Agreement Management is to ensure that the activities described in agreements are being performed, and that evolving products and services will satisfy requirements described in agreements.

Major points addressed
Supplier Agreement Management begins after award of the agreement or contract and ends when all activities relating to the agreement are satisfied. Supplier Agreement Management involves inputs and guidance to the supplier's effort to meet agreed requirements. It includes maintaining visibility into the practices of, and ongoing communications with, the supplier. Visibility and communication help to identify risks and anticipate problems in the performance of the agreement. Activities include evaluating the supplier's performance, and the quality and adequacy of evolving deliverables, including both products and services. Based on the results of those evaluations, the agreement may be modified. Activities also include determining whether to accept the supplier's product or service, based on acceptance conditions stipulated in the agreement.

In addition to coordination of schedules, processes, and delivery of work products, the supplier and acquirer are more likely to succeed if they share a vision of the working relationship. A successful relationship between an acquirer and supplier depends on the capability of both organizations, the communications between them, and on a mutual understanding of each other's expectations.

Goals
1. The documented agreement is kept consistent with the acquirer's requirements and relevant laws, policies, regulations, and other applicable guidance. *(BP 12.03, BP 12.06, BP 12.07)*
2. Supplier performance, processes, products and services are reviewed and monitored to identify problems and to ensure that products and services conform to requirements. *(BP 12.01, BP 12.02, BP 12.04)*
3. Measurements are used to track the supplier's performance. *(BP 12.01, BP 12.02, BP 12.04)*
4. Communications between the acquirer and the supplier are established and maintained to foster a cooperative and productive agreement environment. *(BP 12.02, BP 12.05)*
5. Acceptance of deliverable products or services is based on the supplier meeting the terms and conditions described in the agreement. *(BP 12.08)*

Notes
A supplier is an organization or an individual that enters into an agreement with the acquirer or customer for providing a product or service under the terms of the agreement. The supplier may be called, for example, the producer, developer, contractor, seller, vendor, distributor, importer, assembler or service organization. The supplier can be either external or internal to the organization. An acquirer is an organization, stakeholder or individual that acquires, procures or obtains a system, product or service from a supplier An acquirer could be called a buyer, customer, owner, user or purchaser.

Suppliers include contractors, vendors, partners, or other business units both within and external to the acquirer. The agreement is binding and establishes the requirements for the products and services to be acquired, as well as the basis for acceptance. The agreement establishes the mechanism to allow the acquirer to oversee the supplier's activities and evolving products, and to evaluate products and services being acquired. The agreement also provides the vehicle for mutual understanding of the agreement's requirements between the acquirer and the supplier, and establishes the appropriate mechanisms for working together, throughout the term of the agreement, toward a successful product/service outcome that meets the acquirer's needs. The supplier's deliverables are approved when all acceptance conditions are satisfied. The agreement may be in the form of a Memorandum of Understanding, Memorandum of Agreement, contract, or other documented or verbal understanding. If an agreement exists, the supplier would include the prime contractor or support contractor. If a memorandum of understanding exists, the supplier may be a government agency. Sub-contractors reporting directly to the supplier are not included in this PA.

When suppliers deliver products that do not meet the acquirer's needs, the acquirer has the option to terminate the agreement, change to another supplier, alter its standards and accept the delivered products, or help the supplier or vendor meet the acquirer's needs.

Relationships between this PA and other PAs
Specific activities pertaining to selecting the supplier are addressed in Outsourcing (PA 05). The agreement and typical agreement contents are identified or developed, established, and formalized in Outsourcing (PA 05).

Evaluation (PA 08) practices are related to Supplier Agreement Management practices since evaluations of the product are performed for acquirer acceptance, and the acquirer may formally witness evaluations performed and record results under PA 08. Product and service requirements, developed by the practices of the Requirements process area (PA 02), are the basis of agreements and contractual obligations managed using the practices of Supplier Agreement Management. Supplier Agreement Management uses Risk Management (PA 13) to obtain insight to early problems with the agreement, and provides input to Risk Management through its monitoring function. Project Management (PA 11) may initiate a change in the agreement. Integrated Teaming (PA 14) provides a formal approach to accomplishing close acquirer-supplier interaction through the normal coordination, communication and collaboration practiced in integrated teaming operations. Measures are identified to evaluate the supplier's

performance in Measurement and Analysis (PA 18). Supplier performance management results may be provided to Integrated Enterprise Management (PA 00). Products developed by a development contractor are transitioned to the acquirer after acceptance, using Deployment, Transition and Disposal (PA 09). Configuration Management (PA 16) ensures the integrity of the product or service upon receipt from the supplier. Information Management (PA 17) is useful in maintaining information relevant to agreements. Supplier Agreement Management provides inputs to Quality Assurance and Management (PA 15) relating to the quality of externally acquired products and services.

Base practices list

BP 12.01 **Use planning documents:** Ensure the supplier adheres to acquirer-approved planning documents.

BP 12.02 **Review and monitor agreement performance:** Review and monitor supplier activities through periodic, formal reviews and informal, technical issue interchanges with the supplier, and by quantitative means to continuously determine agreement outcomes versus plans and requirements.

BP 12.03 **Maintain supplier agreement integrity:** Ensure agreements comply with current laws, policies and regulations, and incorporate necessary and approved changes into the agreement.

BP 12.04 **Monitor supplier's plans, processes, activities and products:** Monitor supplier's quality assurance, configuration management, test, corrective action and risk management systems, plans and process activities, results, and products.

BP 12.05 **Foster cooperative and collaborative environment:** Perform activities to foster a partnership between the acquiring organization and the supplier.

BP 12.06 **Analyze and direct agreement activities:** Analyze and direct the performance of agreement activities.

BP 12.07 **Administer supplier agreement:** Ensure the agreement is being maintained and followed, and all changes and records are properly processed, controlled and maintained.

BP 12.08 **Determine product or service acceptance:** Determine whether to accept the supplier's product or service, based on acceptance conditions stipulated in the agreement.

BP 12.01 Use planning documents

Ensure that the supplier adheres to acquirer-approved planning documents.

Description
Review planning documents for compliance with agreed-to requirements and ensure that the supplier's processes, practices, methodologies, and procedures are satisfactory. These are then used by the supplier to oversee the supplier's efforts.

Typical Work Products
- Status against the following types of plans
  - project management plan
  - risk management plan(s) (including programmatic, system, software, etc)
  - software engineering plan
  - software development plan
  - configuration management plan
  - quality assurance plan
  - corrective action system
  - systems engineering management plan (SEMP)
- changes to the plans
- status reports (cost/schedule reports)
- progress reports

Notes
Coordinate and approve changes to these plans with the acquirer before accepting them and permitting the supplier to implement them.

Ensure that plans are maintained to reflect changes in agreements. Review measurements resulting from cost/schedule reporting to understand current agreement outcomes versus plans. The acquirer and supplier maintain ongoing communications and commitments as agreed to by both parties.

BP 12.02 Review and monitor agreement performance

Review and monitor supplier activities through periodic, formal reviews and informal, technical issue interchanges with the supplier, and by quantitative means to continuously determine agreement outcomes versus plans and requirements.

Description
Agreement performance review and monitoring includes reviewing the developer's compliance to developer evaluation processes, attending reviews (both technical and non-technical), reviewing interim work products, and preparing for the delivery of the final work product. Perform trend analysis and other measures of the results of reviews of the supplier's activities to detect and quantify issues in satisfying agreed requirements as early as possible.

Formal reviews include agendas with decisions related to the completion of milestones or achievement of technical and programmatic objectives. Typically these reviews include work product inspection, analysis, or test results summaries, analyses, and recommended actions or decisions. Those participating in the reviews have the authority to assign, accept, and close actions, or to make and approve decisions based on the review results.

Technical issue interchanges are meetings between technical or support groups to learn about expertise, approach, or progress; identify, analyze, and select alternative actions for issues crossing group or element boundaries; plan inter-related activities; or solve problems within the technical or support domain. These group meetings may be informal get-togethers or formal conflict resolution sessions to prioritize the use of scarce resources.

Typical Work Products
- review records
- action items
- plan revisions
- agendas
- status reports
- progress reports
  - results of reviewing system test procedures
  - minutes of reviews
  - results of reviewing traceability of evaluation requirements to test documents (e.g., a Verification Requirements Traceability Matrix)
  - supplier evaluation progress and status reports
  - review of supplier test anomaly reports

Notes
Agreement performance includes evaluation of development and maintenance of products and services. Ascertain compliance of the product or service development, maintenance, documentation and verification with technical, cost, and schedule parameters, and with specifications and standards expressed in the agreement.

Evaluation of deliverables is covered in Evaluation (PA 08). The Supplier Agreement Management PA includes witnessing and examining the results of those evaluations, and managing/administering the agreement appropriately.

Review the supplier's technical, cost, staffing, and schedule performance against the contractor's plan. Ensure that critical resources, dependencies, commitments, nonconformance, risks, conflicts and irreconcilable issues are addressed.

Ensure that the supplier's plan is refined as appropriate.

BP 12.03 Maintain supplier agreement integrity

Ensure agreements comply with current laws, policies and regulations, and incorporate necessary and approved changes into the agreement.

Description
This practice may involve changing the agreement terms and conditions as appropriate. In such a case, ensure that changes to the requirements are coordinated with all affected groups and individuals, such as the contracting official, legal, supplier, and end user, and that they are approved for incorporation into the agreement.

Typical Work Products
- integral agreement
- approval by contracts, legal, user, and supplier
- agreement modifications

Notes
Agreement maintenance is adherence to and compliance with the requirements, relevant laws, policies, regulations, and other legal guidance in the agreement. The agreement must be kept current with requirements throughout the duration of the agreement. This includes the evaluation and management of changes (requirements, constructive changes, non-constructive changes) that are proposed to the supplier agreement.

Supplier agreement integrity is typically maintained by a person who holds the appropriate legal authority to perform agreement administration functions, or who delegates those functions.

BP 12.04 Monitor supplier's plans, processes, activities and products

Monitor supplier's plans and quality assurance, configuration management, corrective action, and risk management systems and process activities, results, and products.

Description
This practice monitors selected supplier systems and processes for compliance with standards and plans to ensure that associated results support and promote attainment of agreement objectives and comply with agreement requirements. Supplier records of quality assurance, configuration management and risk management activity are periodically audited to assess how well the plans, standards, and procedures are being followed. Process compliance can be determined using quantitative means and measures that can be used to identify process- and product-related issues of concern.

Typical Work Products
- audit reports
- coordination meeting minutes
- change requests on quality assurance and configuration management topics between contractor and acquiring project
- risk management reports
- corrective action item records
- quantitative measures
- property control systems

Notes
Coordination between supplier and acquirer reduces redundancy and builds trust in a stable project environment. In particular the quality assurance and configuration management functions permit more trust of the supplier (such as a software or hardware developer for a systems integration unit). PA 08, Evaluation, is used to evaluate the degree of compliance between the supplier's actual products versus their agreed upon requirements.

If the supplier is following the acquirer's process (e.g., support contractor) including the use of that organization's quality assurance and configuration management, this base practice is not applicable.

BP 12.05 Foster cooperative and collaborative environment

Perform activities to foster a partnership between the acquiring organization and the supplier.

Description
Typical activities might include:

- supporting a mutual understanding of the agreement's requirements between the acquirer and the supplier
- maintaining ongoing communication at appropriate levels
- providing formal and informal feedback sessions
- facilitating access to information regarding the status of the supplier's performance and accomplishments
- allowing the supplier to manage the engineering efforts, including engineering evaluation, with minimal interference
- promoting the joint development of solutions to issues by the acquirer and the supplier
- providing timely reviews of submitted material
- requiring that the project team satisfies its commitments to the supplier, such as review of supplier-generated documentation and timely feedback of the results of acquirer evaluations of supplier performance, products, and services

Typical Work Products

- communications plan
- procedures for handling issues and concerns not reconcilable at lower levels
- methods of identifying and mitigating risks
- technical exchange meeting minutes

Notes
Process and product measurements may be used as a common basis to communicate the requirements and the status of the project.

BP 12.06 Analyze and direct agreement activities

Analyze and direct the performance of agreement activities.

Description
Regular analysis of supplier activities against plans and standards provides continuous insight into the supplier's capability to deliver a product or service. Analysis of activity cost and schedule status against work plans not only provides indicators of a supplier's efficiency in providing products and services, it also provides the basis for any adjustments in the management and performance of activities. This in turn provides for direction of agreement activities according to plans, or according to plan amendments resulting from activity analysis.

Typical Work Products
- original contract
- contract modifications
- contract letters
- requests for waivers
- show-cause letters
- contract case file

Notes
Agreement analysis and direction is typically performed by a person who has the technical skill to analyze and determine agreement activities. Decisions regarding agreement direction are transmitted through an official who holds the appropriate legal authority to change the agreement to reflect changes in direction.

Evaluation of the agreement deliverables is covered in Evaluation (PA 08). The Supplier Agreement Management PA includes looking at the results of those evaluations and managing the agreement appropriately.

BP.12.07 Administer the agreement

Ensure that the agreement is being maintained and that all agreement-related changes and records are properly processed, controlled, and maintained.

Description
Administering the agreement involves the day-to-day processing, control and maintenance of the agreement as it is being executed. This can include recordkeeping and file maintenance, issuing and tracking the use and management of government property, issuing agreement modifications, recording acceptance of contract deliverables, reviewing and processing invoices for payment, and performing contract terminations and contract releases. It ensures that acceptance of products or services is recorded and processed.

Typical Work Products
- original contract
- contract modifications
- contract letters
- contract releases
- invoice certifications
- requests for waivers
- show-cause letters
- contract case file

Notes
Agreement administration is typically performed by a person who holds the appropriate legal authority to perform agreement administration functions, or who delegates those functions.

Evaluation of the agreement deliverables is covered in Evaluation (PA 08). The Supplier Agreement Management PA includes looking at the results of those evaluations and managing/administering the agreement appropriately.

BP 12.08 Determine product or service acceptance

Determine whether to accept the supplier's product or service, based on acceptance conditions stipulated in the agreement.

Description
This practice ensures that acceptance of a supplier's product or service is based on agreed evaluation criteria, and is conducted as planned and described in the supplier agreement. It also ensures that acceptance is made by persons specifically authorized to accept a product or service. Suppliers' deliverable products or services are evaluated against agreed requirements and acceptance criteria. Product or service acceptance by the acquirer is required before payment, or other form of compensation, is made to the supplier. Acceptance by the acquirer may be the mechanism that authorizes the supplier to proceed with delivery of more products and services to other locations or customers.

The extent of supplier involvement in acceptance evaluations should be defined. The acquirer conducts acceptance review and acceptance testing of the deliverable product or service, and accepts it from the supplier when all acceptance conditions are satisfied. After acceptance, the acquirer should take the responsibility for the configuration management of the delivered software product.

Typical Work Products
- signed delivery receipts
- approved acceptance results
- joint acceptance inspection results
- completed delivery forms

Notes
Acceptance criteria should be specified and maintained in the supplier agreement. Acceptance may signify the completion of the agreement, and may therefore be accompanied by formal documentation to that effect. Agreements may include provisions for conditional acceptance or for alternative acceptance conditions. In such cases, acceptance conditions must be formally approved and an understanding and authorization for the supplier to proceed with product or service delivery is documented. Formal acceptance of a product or service must be made by an authorized individual.

PA 13: Risk Management

Process Area Summary

Purpose
The purpose of Risk Management is to identify and analyze risks to the achievement of project objectives and to execute plans that reduce the likelihood and/or consequence of risks that meet mitigation criteria.

Major points addressed
The Risk Management process area involves developing life cycle risk management approaches that specify the processes and methods used to identify, assess, monitor, and mitigate project risks. Risks are identified by evaluating project characteristics in the context of historical sources of risk. Project risks are analyzed to quantify their likelihood or occurrence and severity of consequence. Appropriate risk mitigation actions are selected based on analysis of alternatives and established action thresholds. Risks and the effectiveness of mitigation actions are monitored and evaluated for corrective action.

Goals
1. A risk management strategy is established and used that includes the methods and parameters for management of risk. *(BP 13.01)*
2. Risks are identified and assessed for their likelihood of occurrence and consequence. *(BP 13.02, BP 13.03)*
3. Risk mitigation is performed when analysis indicates action. *(BP 13.04, BP 13.05)*
4. Risk mitigation actions are monitored to determine their effectiveness and corrective action is taken as needed. *(BP 13.05)*

Notes
The scope of this process area includes the total project effort for products and services. This process area continues throughout the life of the project.

All product development and service efforts have inherent risks, some of which are not easily recognized. The likelihood of risks should be sought out throughout the life of the project as risks can occur in any phase, including operations, maintenance, support, service life extension, and disposal. Poor risk management is often cited as a primary reason for unsatisfied stakeholders, poor performance, and/or cost or schedule overruns. Early detection and reduction of risks avoid the increased costs of reducing risks at a more advanced stage of development or dealing with realized problems should the risk item materialize. The principles of risk management are readily scaleable for a wide range of project size, complexity, and type of product or service.

This process area covers the classical aspects of risk management: planning and strategy, identification, analysis and prioritization, mitigation planning, and monitoring of mitigation actions and potential risk areas.

Relationships between this PA and other PAs

The activities and results of all process areas should be examined by Risk Management to identify and manage appropriate risk areas. The risk management approach is incorporated into risk management plans by activities of the Project Management (PA 11) process area. Although risks may arise in any activity, project success is especially sensitive to risks in technical activities. Risks associated with incomplete, poorly stated, or ill-defined requirements should be identified during performance of the Requirements (PA 02) process area activities. The activities of Design (PA 03) should be reviewed for risks associated with the development of product and service technical approaches and design solutions. The level of risk should be a consideration in Alternatives Analysis (PA 04) analyses and selection criteria. Risk should be considered when establishing Integration (PA 07) and Evaluation (PA 08) strategies. Outsourcing (PA 05) and Supplier Agreement Management (PA 12) activities should be reviewed for risks relating to acquisition of products and services from external sources.

Base practices list

BP 13.01 **Develop risk management approach:** Establish and maintain an approach for managing risk that is the basis for identifying, assessing, mitigating, and monitoring risks for the life of the project.

BP 13.02 **Identify risks:** Identify project risks by examining objectives, alternatives, and constraints in the context of established sources of risk.

BP 13.03 **Assess risks:** Assess risks to determine their likelihood of occurrence and the consequences if they occur.

BP 13.04 **Develop risk mitigation plans:** Develop risk mitigation plans for risks that meet risk action criteria defined by the risk management approach.

BP 13.05 **Implement and monitor risk mitigation plans:** Implement, monitor, and control risk mitigation activities in accordance with risk mitigation plans.

BP 13.01 Develop risk management approach

Establish and maintain an approach for managing risk that is the basis for identifying, assessing, mitigating, and monitoring risks for the life of the project.

Description
The risk management approach should include identification of members of the risk management team; identification of team and individual responsibilities; methods and tools to be employed in risk identification, assessment, and mitigation; and methods of tracking and controlling risk mitigation activities. The approach should also provide for the assessment and communication of risk management results. Stakeholders, including project staff, the program management team, and the developing and maintaining organization should be involved in establishing the risk management approach.

Typical Work Products
- risk management approach
- definition of method and parameters for assigning risk likelihood of occurrence
- method of quantifying risk consequences
- risk sources list
- categories of risk
- criteria for initiating risk mitigation actions

Notes
The risk management approach should be appropriate for the size and type of project. Variable aspects include the appropriate level of project resources, number of personnel involved and meetings or reviews. Examples of likelihood of occurrence parameters include probability of occurrence and high/medium/low. An often-used method of determining likelihood of occurrence is by surveying experts or project staff who have worked on similar projects. The characterization of impact ranges from qualitative (e.g., low/moderate/severe) to quantitative, such as the cost in dollars and/or the days of schedule slip. The method of determining overall risk usually involves some combination of the likelihood and the impact, such as multiplying the likelihood probability times the dollar value of the impact, or simply associating the qualitative likelihood (e.g., high/ medium/low) with the impact (e.g., severe/moderate/low). Examples of criteria for initiating risk mitigation actions include risk greater than low-likelihood/low impact and probability of occurrence multiplied times impact that exceeds some percent of the project budget.

Additional Practice Guidance

- Establish risk management parameters such as risk action criteria or thresholds, definition of measures for risk likelihood and risk impact, risk categories, and risk sources.
- Acquire or establish a common risk classification scheme or risk taxonomy to categorize risks. This taxonomy contains the history of risks for each category and the area of impact of the risk, i.e., performance, cost, schedule, and technical.
- Recommend schedules and methods to Project Management for reviewing risks and risk mitigation effectiveness.

BP 13.02 Identify risks

Identify potential project risks by examining objectives, characteristics, alternatives, and constraints in the context of established sources of risk.

Description
Examine the project objectives, project plans (including activity or event dependencies), requirements, and characteristics of the design and target environment in an orderly way to identify probable areas of difficulty, what might cause harm or loss, and what can go wrong. Use proven methods of risk identification, such as risk source checklists, interviews with subject matter experts, brainstorming with teams, lessons learned documents, trend analysis, failure analyses, and decision trees. Review all project activities and aspects of the product or service lifecycle. Document the identified risks and their root cause.

Typical Work Products
- list of identified risks (risk register input, risk data base input, risk taxonomy and categories)
- risk worksheet inputs
- risk root cause
- risk source identified
- risk point of contact identified
- risk unique identifier
- risk name

Notes
Risks that have been identified as a part of the risk mitigation plans are reviewed and additional risks are identified. Typical risk lists are used as possible sources for common risk issues found in similar projects. Screening criteria or expert opinion may be useful in identifying those risks that merit further consideration or analysis.

The sources of risk include technical (e.g., feasibility, operability, producibility, testability, and systems effectiveness); cost (e.g., estimates, goals); schedule (e.g., technology/material availability, technical achievements, milestones); and programmatic (e.g., resources).

Additional Practice Guidance
- Review established categories or sources of risk such as cost, schedule, technical, procured product interfaces, staff skills, and requirement issues to aid in risk identification.
- Solicit experts to aid in identifying risks.
- Review lessons learned from other programs as sources of risk (find out where problems have arisen in similar contexts).

- Review all elements of the work breakdown structure as part of the risk identification process in order to help ensure that all program aspects have been considered.
- Identify the initiating events associated with each risk in each risk category.
- Define the interrelationships between sources of risk where there is any coupling.
- Review mitigation activities to identify new risks.
- Factor system validation issues into risk analysis.

BP 13.03 Assess risks

Assess risks to determine their likelihood of occurrence and the consequences if they occur.

Description
Estimate the likelihood of occurrence of risks and the potential consequences if they occur, using parameters and measures established by the risk management strategy. Analyze the risks independently of one another and understand the relationships between risks. The analysis methodology should take into account factors such as the probability of failure due to the maturity and complexity of the technology. Identify those risks that should be watched and those that meet established criteria for mitigation.

Typical Work Products
- risk assessment (likelihood and consequence)
- probability of occurrence
- occurrence consequence
- risk watch list
- list of risks to be mitigated
- prioritized risk list

Notes
Risk depends on the probability of occurrence and the consequences of occurrence. Risk is assessed for program, product, and process aspects. This includes the adverse consequences of process variability.

A criteria table may be developed to provide guidance on the project's assessment of the criticality of impact areas. For example, performance may have a higher criticality than cost. If the project is integrated into a larger program or effort, then a method (e.g., criteria table or template) must be used such that risks can be compared across different projects as well as rolled up to a higher level. Risk templates can be used to determine likelihood and consequence levels. The risk quantification method established in the risk management strategy (e.g., high/medium/low; probability of occurrence/cost-if-occurs) is used to quantify risks. Quantification of risks should consider the interdependency of risks. Independent reviews of risk analyses should be considered.

Additional Practice Guidance
- Establish cause and effect relationships for each risk.
- Analyze each risk for potential coupling to all other identified risks.
- Establish a risk resolution date for risks being "watched" by which time the risk must be resolved or its mitigation planned.

BP 13.04 Develop risk mitigation plans

Develop risk mitigation plans for risks that meet risk action criteria defined by the risk management approach.

Description
Consider alternative courses of action (mitigation approaches) for mitigating risks and use an appropriate level of decision analysis to select a mitigation approach for each risk that meets action criteria. Mitigation includes actions to lower the likelihood of occurrence, lessen the consequences, accept the risk, or transfer the responsibility outside the project.

Typical Work Products
- alternatives for risk mitigation
- mitigation option trade studies
- risk mitigation plans
- documentation and rationale for the selected mitigation approach

Notes
Depending on the level of risk, a risk may be assigned for monitoring or for mitigation. The cost versus benefit of mitigation should be considered in developing the risk mitigation plan. The risk mitigation plan should include mechanisms for detecting risks introduced by the mitigation actions.

Examples of activities to mitigate risks:
- To address the risk that the delivered system will not meet a specific performance requirement, build a prototype of the system or a model that can be tested against the requirement. This type of mitigation strategy lowers the probability of risk occurrence.
- To address the risk that the delivery schedule will slip due to a subsystem not being available for integration, develop alternative integration plans with different integration times for the risky subsystem. If the risk occurs (i.e., the subsystem is not ready on time), the impact of the risk on the overall schedule will be less. This type of mitigation strategy lowers the impact.

Additional Practice Guidance

- Document risk reduction profiles and review them for appropriateness.
- Develop alternative courses of action, work-arounds, avoidance, control, and fall-back positions with a recommended course of action for each risk.
- Focus mitigation resources and controls on system elements that are the root cause of the risk.
- Where tolerable, accept the risk and take no action.
- Where an avoidance strategy can be identified, and that action has a positive balance of cost, schedule, and performance benefit to the organisation, then take the avoidance action.
- Use validated models, simulations, and prototyping to reduce cost and risk of system development.

BP 13.05 Implement and monitor risk mitigation plans

Implement, monitor, and control risk mitigation activities in accordance with risk mitigation plans.

Description
Risk mitigation activities are implemented in accordance with the risk strategy and risk mitigation plans. Risk mitigation and handling activities are monitored to ensure that the desired results are being obtained. By monitoring the risk mitigation plans, predetermined baselines may be used to trigger corrective actions. Control actions may address either lowering the probability that the risk consequence will occur or lowering the extent of the damage the risk causes if it does occur.

Regularly, examine the results of the risk mitigations that have been put into effect, to determine whether the mitigations have been successful, and whether any new risks have been introduced.

Typical Work Products
- updates to the likelihood of occurrence
- updates to the assessed impact
- cost, schedule and technical progress for planned mitigation actions
- adjustments to risk watch list
- risk status

Notes
Risk mitigation monitoring and risk mitigation action item management should be integrated with project monitoring and control activities.

Additional Practice Guidance
- Document risk analysis results and mitigation plans.
- Monitor and re-evaluate risks at appropriate milestones.
- During risk monitoring, identify and analyze new risks and take corrective action.
- Maintain a history of risks and risk actions throughout the life of the product or service.
- Track the change in risk parameters for each risk
- Evaluate and manage new risks introduced by the risk mitigation activities.

PA 14: Integrated Teaming

Process Area Summary

Purpose
The purpose of the Integrated Teaming process area is to identify and maintain the disciplines and stakeholders necessary to effectively accomplish appropriate multidisciplinary/cross-functional missions, to create integrated teams as appropriate, and to establish and maintain a supportive teaming environment.

Major points addressed
Integrated teaming involves establishing multidisciplinary and/or cross-functional teams composed of the necessary discipline and stakeholder members to produce outcomes satisfying user or customer needs. These teams bring together the unique expertise and concerns of each discipline and stakeholder in a collaborative effort that features authority and shared accountability by team members for achieving common goals and objectives.

Integrated teams are enabled to perform successfully through establishment of shared vision, goals and objectives, and the use of processes and methods for achieving interdisciplinary and cross-functional coordination, collaboration, communication, and conflict resolution and decision-making.

In addition to equipping teams with these tools and capabilities, the active assistance of participating and affected organizations is applied to maintain a support environment necessary for team operations. This cooperative teaming environment enables organizations to use integrated teams for any appropriate application and for any duration, such as the full life cycle of a product or service.

Goals
1. Integrated teams composed of appropriate disciplines and stakeholders are established and maintained. *(BP 14.01, BP 14.02, BP 14.03)*
2. Team processes and methods are established and maintained for effective coordination, collaboration, communication, conflict resolution and decision-making. *(BP 14.03, BP 14.04, BP 14.05, BP 14.06)*

Notes
Key Definitions:
- Integrated team vs. matrix team - An “integrated team” formally combines team members from *both* the required skill areas and all stakeholder (user/customer) organizations to collaboratively accomplish the team’s goals and objectives. Its members are usually empowered, within reasonable limitations, to make real-time, team-based (consensus) decisions in conducting its work, and are held mutually accountable for the results. These characteristics of an integrated team should be reflected in the team’s charter and be verifiable from the team’s actual makeup,

internal functioning, and overall mode of operation. In contrast to the "integrated team", the "matrix team" focuses on having the right mix of skills on the team to get its job done, but the decision-making usually rests with the team leader. This feature of matrix teams can create a weak sense of mutual accountability of team members for team outcomes.

- Organization - The term "organization" as used in this PA refers to organizational entities that are responsible for specific line management functions within the corporate organization, and those groups external to the corporate organization needed as participants on integrated teams.

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- Multidiscipline and cross-functional - "Multidiscipline" refers to the various skills needed on an integrated team; "cross-functional" refers to the selected functional organizations, inclusive of all appropriate stakeholders, necessary to be actively involved in performing an integrated team's mission. "Cross-functional" team members include both the users and customers of the team's output and key suppliers involved in the team's efforts.

- Teaming environment - The "teaming environment" refers to the tools, techniques, methodologies, processes, operating conditions (including appropriate empowerment), and support infrastructure necessary for integrated teams to function successfully in collaboratively executing team activities and achieving their missions.

Other Points:

- Integrated team outputs - The end result of an integrated team effort, or integrated solution, may be a decision on a major issue, a strategy or a plan affecting all team member groups, or producing and delivering products or services.

- Example of disciplines for integrated team makeup - For teams engaged in delivering products or services, the disciplines required on the team may include, but not be limited to: design, development, test, reliability, maintainability, operations, quality, manufacturing, supportability, human factors, logistics, safety, security, and user or customer expertise.

- Criteria for using integrated teams - *Not all situations call for integrated teams*. The basic criteria for using integrated teams are: (1) a mission, work objective or task requiring interdisciplinary and/or cross-functional, collaborative participation; (2) a need for shared accountability by participants for team results, where the participating organizations and individuals are held mutually responsible for team activities, performance and outcomes; and, (3) a need to streamline and expedite coordination and collective decision-making by empowering teamwork at the lowest practicable level. The most prevalent example of integrated teams is for missions involving life cycle responsibility for the design, development and delivery of products or services.

Relationships between this PA and other PAs

Because this PA defines the practices required for efficient/effective coordination and collaboration among members of teams, among affected teams, and among the managers and supervisors of participating discipline and stakeholder organizations, it can be used by all process areas. With respect to PAs 00, 10 and 11, this PA provides the integrated teaming of disciplines and appropriate functional participants necessary for collaboratively managing and executing projects, and accomplishing other enterprise-wide goals and objectives. For PAs 05 and 12, this PA provides for inclusion of appropriate suppliers and contracting officials in the team's operation. In the case of PA 04, PA 14 can create a multidisciplined/cross-functional body for analysis of alternatives and for structured decision-making.

This PA is also related to Integrated Enterprise Management (PA 00), Training (PA 22), Information Management (PA 17), and Measurement and Analysis (PA 18) in that the base practices of these PAs contribute to enabling Integrated Teaming and the accompanying environment for effective coordination, collaboration, communication, and performance improvement. On another point, this PA extends the definition of organization to others outside the enterprise, such as customers and suppliers, since stakeholders necessary for team participation may be from outside the organization.

Base practices list

BP 14.01 **Develop and communicate team goals**: Develop team-shared vision, goals and objectives.

BP 14.02 **Establish and maintain integrated teams**: Where the application is appropriate, establish and maintain empowered teams that integrate the necessary disciplines and stakeholders at the proper points in time throughout the life of a product or service to collaboratively accomplish team goals.

BP 14.03 **Establish and maintain a collaborative workplace:** Create a working environment conducive to effective cross-discipline/cross-functional coordination and communication.

BP 14.04 **Establish coordination and communication methods:** Establish methods for coordination and communication among team members and with affected teams, organizations and individuals.

BP 14.05 **Establish resolution methods:** Establish and use methods for identifying and resolving issues cutting across disciplines and stakeholder interests, for decision making, and for escalating unresolved issues to management.

BP 14.06 **Communicate integrated team activity results:** Communicate results of integrated team activities to team members and to other teams, organizations and individuals engaged in, or affected by, the team's work project(s)/products.

BP 14.01 Develop and communicate team goals

Develop team-shared vision, goals, and objectives.

Description
For successful team efforts, each team member and the direct support staff must embrace and work toward the same shared vision, goals, and objectives. These must be collaboratively developed and communicated to every member of the team and other affected teams, organizations, and individuals.

A shared vision for the integrated team is established and maintained that is aligned with any overarching or higher-level enterprise vision. This shared vision anchors the team's governing ideas and operating principles, and provides the basis for the goals and objectives to be achieved. It guides the activities of the team and helps drive the team to achieve its mission. Further, the shared vision and associated goals and objectives facilitate the necessary collaboration and coordination for effectively working together, and helps to attain unity of purpose among team members.

Typical Work Products
- mission, goals, and objectives
- excerpts from the technical management plan
- team-shared vision
- team charter documenting agreement on vision, mission, goals, and objectives
- memos of agreement/understanding depicting participating organization concurrence on team's vision, mission, goals and objectives

Notes
Goals (which are long-term in nature) should flow from and include everything required to accomplish the team mission. Objectives are planned short-term actions carefully chosen to contribute toward accomplishing each goal. New objectives may need to be added over time to enable the team to eventually fully achieve each of its goals.

Examples of team goals and objectives:
- breakout of specific accomplishments over the long term that are necessary to achieve the mission (team goals)
- planned project or programmatic accomplishments, such as cost/schedule, quality/cost, and quality/schedule targets (team objectives)

BP 14.02 Establish and maintain integrated teams

Where the application is appropriate, establish and maintain empowered teams that integrate the necessary disciplines and stakeholders at the proper points in time throughout the life of a product or service.

Description
The integrated team brings together the necessary disciplines and skills, plus the stakeholders affected by, or having a major interest in the team's outcomes, to collaboratively develop and deliver the team's work product. These team members are empowered by their organizations and management to plan, execute, and implement collaborative team-based decisions, and are held collectively accountable for accomplishing the team's mission.

The integrated team receives its assignment and support resources from its sponsor, which can be a person or a group (e.g., a senior-level enterprise team, a manager of a major functional organization, a project manager, or even another integrated team).

Operation of the integrated team is governed by established principles that drive disciplined operation that saves time and contributes to high performance and productivity.

Each team member's roles and responsibilities are clearly defined, based on the member's skills, stakeholder affiliation, other commitments, and the particular tasks and projects being undertaken by the team. The allocation of roles and responsibilities provides an understanding among members of each other's contribution, level of involvement and role in decision-making.

The team's internal operating practices and ground rules are collaboratively established and maintained to define and control how the team will operate routinely, as well as its interaction with interfacing teams, other organizations, and individuals.

Typical Work Products
- list of results the team is expected to achieve for its tasks or short-term team objectives
- list of essential disciplines or functions required to perform the team's work
- list of the knowledge, key skills, and critical expertise
- initial profiles of team skills and knowledge for the core team and the extended team
- revised skills matrix and knowledge profiles
- memos of agreement/understanding among participating organizations indicating concurrence and support for the team and its charter

- draft of team charter containing:
  - list of team members by discipline and stakeholder organization
  - documented vision statement, mission, goals, and objectives
  - descriptions of roles and responsibilities of member organizations and team member participants
  - specific areas of empowerment needed by the team
  - internal operating processes, practices, and ground rules
  - procedures for work expectations and performance measures (metrics areas)

Notes
Integrated team members:
- provide the needed skills and expertise to accomplish the team's tasks (objectives)
- provide the advocacy and authoritative representation necessary to address all essential aspects of the team's mission, goals, and objectives
- collaborate internally among themselves and externally with other teams and stakeholders as appropriate
- share a common understanding of the team's vision, mission, goals, and objectives.

As the team effort proceeds through the life cycle of its assigned mission or task, the activity levels of critical disciplines vary, and the types of disciplines and specialists may need to be revisited. The initial focus should be on attaining complete coverage, not limiting the number or origin of participants. Any needed adjustments in team skill makeup are made through collaborative agreement of team members and their organizations. The same approach applies to the stakeholder composition of the team. Maintaining the team's discipline and stakeholder membership current with the changing needs of each stage of the product/service life cycle contributes to the team's ability to accomplish its mission effectively.

The following should be accomplished collaboratively by the team members and agreed to in documented form, such as a team charter:
- Define and list the team objectives, drawn from the goals that flow down from its mission statement.
- Identify specific strategies for achieving the team objectives.
- Identify how team and individual performance and accomplishment are measured.
- Identify critical success factors.
- Map the roles, responsibilities, and expertise of the team members to the team tasks and expected deliverables.
- Define the working relationship and reporting structure for team members.
- 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.
- Define the degree of collective decision-making and level of consensus needed for team decisions.
- Define how conflicts and differences in opinion within the team are addressed and resolved.

- Establish and maintain the work product ownership boundaries among interfacing teams within the project or organization.
- Establish and maintain interfaces and processes among interfacing teams for the exchange of inputs, outputs, or work products.
- Develop, communicate, and distribute among interfacing teams commitment lists and work plans related to the work product or team interfaces.

Additional Practice Guidance

- Define team tasks (objectives) required to deliver the assigned work products.
- Decide which tasks (objectives) need team or individual member input.
- Identify the core competencies on which to base the integrated team's activities in order to sustain or achieve desired capability.
- Establish knowledge and skills profiles underlying each core and extended team competency.
- Define staffing and competency requirements.
- Establish relevant criteria for evaluating team members against established knowledge and skills profiles.
- Utilize the criteria to qualify appropriate candidates against the knowledge and skills profiles.
- Identify and orient team members to best contribute to the team's capability.
- Assess and determine the integrated team's capability to meet its objectives based on initial staffing and positioning.
- Proactively emphasize the inclusion, and active participation, of appropriate disciplines and stakeholders on the team throughout its life cycle.

BP 14.03 Establish and maintain a collaborative workplace

Create a working environment conducive to effective cross-discipline/cross-functional coordination and communication.

Description
Team participants, both the team members and organizations represented on the team, need to know and appreciate the issues and interests important to those disciplines and stakeholders involved in the development, deployment, and use of the team's work products. This cross-discipline/cross-functional knowledge and appreciation is established and maintained, not only among team participants, but also with other teams with which the team interfaces and those external organizations and individuals affected by the team's activities and decisions.

The organizations participating on the team as discipline and stakeholder members agree to aid and support the team by helping create a work environment characterized by mutual trust, collaboration, attention to team needs, and granting the right level of empowerment to enable the team to function effectively. Further, these organizations recognize, model, lead, and promote the partnership mode of operation needed for the integrated teaming environment.

Typical Work Products
- team member and participating organization roles/responsibilities matrix
- team charters depicting inclusion of appropriate membership and collaborative mode of operation and team empowerments
- memos of agreement/understanding among organization managers supporting team charters and collaborative activities in general
- briefings by participating discipline and functional organizations
- team conferences for briefing/discussing/detailing team mission, goals, objectives
- team progress reviews on mission-related plans and accomplishments
- issue tracking and action item resolution records

Notes
Team members representing key disciplines and functional groups provide overviews of the work product, a unique perspective, and the ability to explain their issues of concern to teammates and to other teams and organizations.

Knowing and appreciating the other individual's or organization's concerns is the first step to achieving a cooperative, harmonious work environment. The objective is not to create a group of experts; it is to create a team of skilled individuals who are aware of each other's issues, special interests and technical concerns. Proper consideration of each concern has a positive impact on the quality of the team's work products.

Consideration of the specialty disciplines and the key stakeholder groups on a continuing basis, and especially early in the team's life cycle, is key to successful team outcomes.

Example activities

- kickoff meeting with technical approach presentations, discipline issues, and action item lists
- technical seminars.
- periodic recognition of key discipline/functional contributions
- status reviews of team activities with stress on examining issues and tracking action items
- joint senior and mid-level manager reviews of integrated team status and operations, and status of team project performance

BP 14.04 Establish coordination and communication methods

Establish methods for coordination and communication among team members and with affected teams, organizations and individuals.

Description
In addition to understanding their relative roles, responsibilities and what information to share, team personnel are skilled in techniques of sharing knowledge, i.e., transferring information from an individual team member or team to others who need it. They also recognize that discipline specialties and functional organizations represented on the team may have their own processes that should be integrated with the processes being used by the team. Methods are designed and in place to enable the coordination and communication of these and other matters involved in integrating skills, capabilities, special needs, and interests of the multidiscipline and stakeholder participants on the team.

Typical Work Products
- methods or procedures for coordinating integrated project status and team activities
- methods or procedures for communicating team activities and progress in accomplishing objectives and work plans
- team communication plan
- integrated information infrastructure
- provisions and procedures for reviews, conferences, and events designed for sharing information and coordinating problems and issues
- copies of agendas and meeting announcements
- team meeting and conference minutes

Notes
Information sharing may center on an automation strategy that allows individuals and the team to share data through an automation tool suite. Alternatively, this might be done through a teaming strategy, where individuals would share information in accordance with the particular teaming structures used.

Examples of methods/techniques to communicate:
- electronic mail decisions with rationale
- use of the project's selected automation toolset
- teleconference action item/issue review
- meetings and conferences

Additional Practice Guidance
- Establish tools, methods, facilities (e.g., team rooms), and an information infrastructure that eases and supports interdisciplinary coordination.
- Provide means for individuals and teams to acquire skills that facilitate interdisciplinary cooperation, such as communication skills, team problem solving, and active listening.

- Plan for and provide regular exchanges of technical information and issue identification and resolution among all stakeholders, including customers.
- Establish a mechanism to ensure compliance with commitments made among groups.
- Espouse and model appropriate communication skills and interdepartmental cooperation on the part of upper management.
- Coordinate interface definition, design, and changes between affected teams and individuals throughout the life cycle.

BP 14.05 Establish resolution methods

Establish and use methods for identifying and resolving issues cutting across disciplines and stakeholder interests, for decision making, and for escalating unresolved issues to management.

Description

Predetermined techniques are established and used for resolving issues and conflicts that arise among the disciplines and stakeholder organizations during the course of the team's work. The techniques are designed to accommodate the time available to come to resolution, the severity of the issue, and the related consequences of the issue. Prevention activities include having representatives of the disciplines, stakeholders, and later life cycle teams review and coordinate early life cycle outputs on which they depend as inputs. Issues are documented and tracked to closure. Team decision making methods are established.

Typical Work Products

- issue resolution methods, such as the following:
  - Pugh's Controlled Convergence technique
  - Consensus-building technique
  - negotiation techniques
  - Quality Function Deployment technique
  - autocratic edict
  - consensus
  - arbitration rules
  - written procedures for conflict/issue resolution
- team decision making methods

BP 14.06 Communicate integrated team activity results

Communicate results of integrated team activities to team members and to other teams, organizations and individuals engaged in, or affected by, the team's work project(s)/products.

Description
The results of interdisciplinary/cross-functional team activities will include the alternatives considered, the decisions made, and the rationale for the decisions. These results are communicated promptly to affected team members, teams, organizations and individuals using methods of BP 14.04, and others, as appropriate.

Efforts are made to ensure that each discipline understands the other's contributions and importance to the particular team effort. Likewise, disciplines and stakeholders are made to understand and appreciate the concerns of individual stakeholders, particularly end users and customers. Communicating the team's activities and decisions while preserving these important relationships involves identifying when and how information is exchanged, who is affected by the information, who is notified when information is developed and changed, and when key team decisions are weighed and made.

Typical Work Products
- results of interdisciplinary or stakeholder-sensitive activities
- meeting minutes
- decision database
- commitments
- technical reviews
- communications media (including teleconference, video conference, inter/intranet)
- electronic mail and conventional mail/distribution lists
- communication plan

Additional Practice Guidance
- Capture and communicate inter-group and inter-team coordination activities and the results of those activities.

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PA 15: Quality Assurance and Management

Process Area Summary

Purpose
The purpose of Quality Assurance and Management is to ensure the quality of the product or service, ensure the quality of the processes used to create or provide the product or service, and provide management with appropriate visibility into the processes and product.

Major points addressed
High-quality products and services are consistently produced when there is a way to continuously measure and improve quality. This focus on quality must be adhered to rigorously and throughout the life cycle. Quality Assurance (QA) involves a planned and systematic means for assuring management that defined standards, practices, procedures, and methods of the process are applied. Key aspects of the process are monitoring, measurement, analysis, and identifying corrective and preventive actions. Also, an independent channel for reporting quality issues should be established. Management is responsible for managing the Quality Management System.

Defects that were encountered in the past are analyzed and specific actions are taken to prevent the occurrence of those types of defects in the future. The defects may have been identified on other projects, as well as in earlier stages or tasks of the current project.

Goals
1. Adherence of work products, services, and activities to applicable standards, procedures, and requirements is verified objectively. *(BP 15.01, BP 15.02, BP 15.03)*
2. Noncompliance issues are tracked and those that cannot be resolved at the project level are addressed by senior management. *(BP 15.01, BP 15.04)*
3. Affected groups and individuals are informed of quality assurance activities and results. *(BP 15.04)*
4. Causes of defects are sought out, identified, prioritized, and corrected and methods of elimination and prevention are evaluated. *(BP 15.05)*
5. Quality improvement opportunities are initiated with the appropriate stakeholders. *(BP 15.06)*

Notes
A successful quality program requires development of a strategy and integration of the quality efforts throughout the project/organization team and support elements. Effective processes provide mechanisms for building in quality and reducing dependence on end-item inspections and rework.

Primary responsibility for "building in" quality lies with the builders. A quality management process helps to ensure all aspects of quality management are seriously considered and acted upon by the organization and reflected in its products. This

increases the confidence of developers, management, and customers in the product or service's quality.

The word “objectively” is used throughout this PA. Teams should assume responsibility for their product and service quality, rather than relying on inspections or a quality organization; however, objectivity is typically not achieved by self-monitoring, management tracking, and customer review/audit. Examples of possible ways of obtaining objectivity include independent QA audits, testing (other than self-testing), and peer reviews. A person or group review by people who were not involved in developing the work product provides a different (objective) perspective that often results in discovering defects missed by developer-reviewers. The word “audit” is used to mean the same as “internal audit.”

Relationships between the PA and other PAs

Quality Assurance and Management (PA 15) provides an objective view that ensures planned processes are implemented and that products and services meet their applicable standards and requirements. Evaluation (PA 08) is the verification and validation of products and services against their technical requirements and needs. This activity supports Quality Assurance and Management by providing additional quality measures and results. Quality Assurance and Evaluation may on occasion look at the same product but from different perspectives. Projects should take care to minimize unnecessary duplication of effort. The Quality Assurance and Management tasks will typically be accomplished by sampling products and processes throughout the life cycle.

Most practices in the Quality Assurance and Management process area are related to the practices in all the other process areas. Of specific relevance is the Project Management (PA 11) process area. Quality Assurance and Management provides management visibility into the quality of products and services provided. As improvement opportunities are identified, appropriate activities are initiated in the enterprise via Integrated Enterprise Management (PA 00), on the project via Project Management (PA 11) and, if applicable, Process Definition (PA 20) and Process Improvement (PA 21) are used to update the processes. The measurement of quality is part of the Measurement and Analysis (PA 18) approach. Integrated Teaming (PA 14) discusses customer interface and communication of quality related information. Customer satisfaction information from the Needs process area (PA 01) can be used improving and maintaining a quality management system and in analyzing quality. In addition, these other process areas provide quality information on products and processes: Evaluation (PA 08), Project Management (PA 11), Supplier Agreement Management (PA 12), Risk Management (PA 13), and Process Improvement (PA 21). Specific causes of issues are analyzed resulting in improvements.

Base practices list

BP 15.01 **Establish a quality management system:** Establish, document, imp1ement, and maintain a quality management system.

BP 15.02 **Monitor process compliance:** Objectively monitor compliance of performed activities with the established processes throughout the life cycle.

BP 15.03 **Monitor product and service quality:** Objectively measure work products and services against the requirements and standards that define them.

BP 15.04 **Record and report results:** Record and report the results of quality assurance activities to applicable stakeholders.

BP 15.05 **Analyze quality**: Analyze quality records and measurements to detect the need for corrective action and develop recommendations for quality improvement or corrective and preventive actions.

BP 15.06 **Initiate quality improvement:** Initiate activities that address identified quality issues or quality improvement opportunities.

BP 15.07 **Evaluate the effect of changes:** Evaluate the effect of changes after they have been implemented.

BP 15.01 Establish a quality management system

Establish, document, implement, and maintain a quality management system.

Description
Determine goals, objectives, criteria, and methods required to ensure the effective operation and control of processes needed for a quality management system. Ensure the availability of information necessary to support the operation and monitoring of these processes.

Typical Work Products
- documented quality management system (e.g., in a quality manual) including:
  - identification of the processes needed for the quality management system
  - the sequence and interaction of these processes
  - criteria and methods required to ensure the effective operation and control of quality processes
  - method to ensure the availability of information necessary to support the operation and monitoring of quality processes
  - method to measure, monitor, and analyze quality processes
  - method to implement action necessary to achieve planned quality results and continual improvement

Notes
A quality management system includes a quality policy and objectives, and provides a means to achieve those objectives.

The extent of the quality management system documentation depends on the following:
- size and type of the organization
- complexity and interaction of the processes
- competence of personnel.

The quality management system is maintained and improved.

BP 15.02 Monitor process compliance

Objectively monitor compliance of performed activities with the established processes throughout the life cycle.

Description
Check that the performed processes and procedures follow the documented processes. Compliance should be objectively checked at appropriate intervals. Deviations from the documented processes and the impact of the deviations should be recorded. The documented processes and procedures are periodically checked to ensure that they adhere to standards and policies. Participate in the preparation and review of plans, standards, and procedures as appropriate. Ensure the opportunity to plan monitoring activities to have the greatest impact on the processes.

Typical Work Products
- recorded deviations from documented processes
- recorded impact of deviations from documented processes
- process quality certification
- process compliance measures
- measures (examples)
  - variance
  - timelines
  - cycle time
  - throughput
  - cost
  - process effectiveness

Notes
Objectivity is typically not achieved by self-monitoring, management tracking, and customer review/audit.

The processes can be monitored in a number of ways, e.g., a designated auditor/reviewer can participate in or observe all or a portion of process activities.

Organizations may wish to determine variances based on periodic increments. For example, if the organization has weekly commitments to deliver or roll-out a product, then it would be wise to measure or determine its progress by measuring variances on a weekly basis. If the commitment is monthly, then monthly measurements would likely be appropriate.

Examples of tools to use in measuring the process include:
- a process flow chart can be used to determine which characteristics should be measured and to identify potential sources of variation, in addition to defining process
- statistical process control on process parameters

BP 15.03 Monitor product and service quality

Objectively measure products and services against the requirements and standards that define them.

Description
The work products and services are measured against the designated standards and requirements throughout the life cycle. Measuring the characteristics of the work products provides an indication of the quality of the product or service. Measurements should be designed to assess whether the work product will meet customer, engineering, and contractual requirements. Product measurements should also be designed to help isolate problems with processes. The plans, processes, and identified deliverable or sample work products are measured before they are delivered to the customer.

Typical Work Products
- assessment of the quality of the product/service (e.g., internal audit report)
- product quality certification
- peer review reports
- product compliance issues
- product quality measures
- usage report
- customer satisfaction

Notes
Everyone should assume responsibility for product quality, rather than relying on inspections or a quality organization to find defects; however, self-review, management review, and customer review/audit do typically not achieve objectivity. Other methods may provide objectivity (e.g., by peer reviews or by testing).

Internal audits should be performed at a predefined frequency against specific predefined criteria and scope.

Examples of measurements used to track product compliance are
- Defect Rate
  - where in the life cycle stage or activity (i.e., design, test) defect was found
  - where in the life cycle stage the defect was introduced
  - by product
  - by severity
  - by type (i.e., hardware, software, documentation)
  - by source (i.e., standard, requirements document)

BP 15.04 Record and report results

Record the results of quality assurance activities and report them to applicable stakeholders.

Description
To improve quality, the participation of all affected parties is required. For the affected parties to be cognizant of their contribution to a problem, they are informed when quality issues are discovered. The results of quality assurance activities are reported to the affected groups. Regular feedback to the owner of the process or product is important.

Deviations, improvements, or other corrective actions to the project's plans, standards, procedures, and processes are reported to the appropriate task leader, manager, or project manager. Senior management addresses issues of noncompliance that are not resolved. Noncompliance issues are periodically tracked until they are resolved. An independent channel for reporting quality issues should be established. Noncompliance issues are managed and controlled. Corrections are verified.

Not only is it important to report results of quality assurance activities, but it is equally important to encourage ideas for improving quality from anyone in the organization (See BP 15.06). Management must demonstrate a long-term commitment to sponsor and implement needed change even when change may be difficult or appear to have a high cost.

Typical Work Products
- environment that promotes quality
- captured inputs and resolutions from workers
- quality issue reports
- internal audit reports
- findings
- discrepancy reports
- causal analysis and resolution records

Notes
A quality environment can be fostered by:
- process action teams
- a quality assurance group with a reporting chain of command that is independent of the project

Record and report the results of quality assurance activities. Ensure the reports are disseminated to the correct audience/decision maker. If verbal reporting is all that is done, there is a risk of not taking action for some critical items. If reporting is merely writing down and posting somewhere, there is a risk of the proper people not being informed in a timely manner.

BP 15.05 Analyze quality

Analyze quality records and measurements to detect the need for corrective action and develop recommendations for quality improvement or corrective and preventive actions.

Description
A mechanism or a set of mechanisms to detect defects and/or the need for corrective actions to process or products must exist. Mechanisms may include procedures, on-line reporting systems, workshops, periodic reviews, peer reviews, customer focus groups, and individuals.

Deviations, improvements, or other corrective actions to the project's plans, standards, procedures, and processes are documented and identified.

Modern tools and techniques exist that help determine root causes of defects and barriers to productivity and process improvements.

Causal analysis meetings with people responsible for performing the tasks and other appropriate stakeholders are typically held shortly after a task is completed. They may be conducted during a task, if and when the number of defects uncovered warrants. Meetings may also be conducted after products are released, if appropriate. Measurement data are analyzed. Review similar defects that may exist in other processes and work products to identify preventive actions.

Defects are identified and analyzed to determine their root causes. The defects are assigned to categories of root causes, such as inadequate training, breakdown of communications, not accounting for all details of the problem, and making mistakes in manual procedures (e.g. typing or keyboarding).

Quality improvement tools are used in a disciplined manner to reduce defects and improve productivity. Training on the use of advanced quality improvement tools is provided.

Typical Work Products
- ongoing database or repository containing deviations, identified needs, process improvements, and product improvements
- clearly described processes, methods, and avenues for getting identified needs into a database or repository
- identified needs for process improvement
- identified needs for product improvement
- analysis of deviations
- root cause analysis
- tools and techniques
  - cause-and-effect diagrams or fishbone diagrams
  - trend reports
  - Pareto charts

  - process maps and models
  - process simulations
- failure analysis
- defect reports (i.e., peer reviews, test, etc.)
- system quality trends
- corrective action recommendations
- categories of root causes
- meeting results
- phase defect (or other problem) was introduced

Notes
Needs for corrective action are detected in this base practice and reported in BP 15.04. Corrective actions taken are addressed in the Project Management process area (PA 11). Additionally, any corrective actions affecting baselined items are tracked and controlled in the Configuration Management process area (PA 16).

Examples of data to be analyzed:
- customer satisfaction and/or dissatisfaction
- conformance to customer requirements
- characteristics of processes, product and their trends
- suppliers
- defects

Examples of measurements that support quality improvement:
- trend analysis, such as the identification of equipment calibration issues causing a slow creep in the product parameters
- standards evaluation, such as determining if specific standards are still applicable due to technology or process changes

Cause-and-effect (fishbone) diagrams capture why a problem occurred in relationship to manpower, machines, material, and methods. Other examples of cause groups, or categories, include:
- inadequate training
- breakdown of communications
- not accounting for all details of the problem
- making mistakes in manual procedures (e.g., typing or keyboarding)
- process deficiency

Error prevention analysis may be performed. This is an objective assessment of each error, its potential cause, and the steps to be taken to prevent it. While placing blame is to be avoided, such questions as mistakes, adequacy of education and training, tools capability, and support effectiveness are appropriate areas for analysis.

BP 15.06 Initiate quality improvement

Initiate improvements that address identified quality issues or quality improvement opportunities.

Description
To continuously improve quality, specific actions are planned and executed. Specific aspects of the process that jeopardize product or process quality are identified, prioritized, and correction is initiated. This includes minimizing cumbersome or bureaucratic systems. Improvement activities may include changes to processes, standards, and policies. Defect information can be used to identify and prioritize root causes so that they may be corrected. More mature projects will also conduct analysis by looking at the common causes of defects and trends to identify opportunities for improvement.

Create an environment that encourages employee participation in identifying, reporting, and solving quality issues. The environment should be such that all stakeholders provide feedback to improve any process. Ideas for improving quality are encouraged and a forum exists that allows each employee to raise process and quality issues freely.

Typical Work Products
- recommendations for improving the process
- suggestion box
- quality improvement plan
- process revisions
- action items
- action plan
- meeting minutes
- revised processes
- environment that promotes quality

Notes
Effective implementation of quality improvement activities requires input and buy-in by the work team. Take the ideas, suggestions, deviations, etc., identified previously and initiate action. Bring the input to the appropriate owner, who should incorporate it into an action plan for implementation.

Management must demonstrate a long-term commitment to the sponsor and implement change even when change may be difficult or appear to have a high cost.

Improvements that affect the enterprise should be launched via Integrated Enterprise Management (PA 00). Those affecting the project should be addressed in Project Management (PA 11) and those that affect the organization should be addressed in Process Definition (PA 20). Process Improvement (PA 21) may also be used.

BP 15.07 Evaluate the effect of changes

Evaluate the effect of changes after they have been implemented.

Description
Once the changed process is deployed, the effect of the new capability must be checked to gather evidence that the process change has corrected the problem and improved performance.

Typical Work Products
- measures of performance and performance change

Notes
An example of a change in the *performance* of the project's defined design process would be a change in the defect density of the design documentation, as statistically measured through peer reviews or evaluations before and after the improvement has been made. On a statistical process control chart, this would be represented by a change in the mean.

An example of a change in the *capability* of the project's defined design process would be a change in the ability of the process to stay within its process specification boundaries. This can be statistically measured by calculating the range of the defect density of design documentation, as collected in peer reviews or evaluations before and after the improvement has been made. On a statistical process control chart, this would be represented by lowered control limits.

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PA 16: Configuration Management

Process Area Summary

Purpose

The purpose of the Configuration Management process area is to establish and maintain data on and status of identified configuration items, analyze and control changes to the identified items, and to establish and maintain the integrity between the identified work products and their data throughout the project's life cycle.

Major points addressed

Configuration Management comprises configuration management strategy, configuration identification, repositories, change control (including version control), status accounting, and auditing and inspection of the work product and environment.

Configuration Management practices apply to all work products and work environments designated for configuration management. It ensures the customer has the correct work product. It also ensures the developer maintains identified configuration items, and can analyze and control changes to those items. Managing the configuration includes providing accurate and current configuration data and status to stakeholders.

The Configuration Management process is applied throughout the project's life cycle: to identify, define, record, and baseline the product and work product definitions; to control their modification and release; to record and report the status of modification requests; and to ensure the continuing integrity of the project definition and working environment.

Goals

1. Configuration items that are to be managed are identified. *(BP 16.01, BP 16.02)*
2. Configuration items are controlled and managed throughout the life cycle. *(BP 16.02, BP 16.03, BP 16.04, BP 16.05)*
3. Status of configuration items is recorded and reported to all stakeholders. *(BP 16.02, BP 16.05)*
4. The integrity of baselines and work products is assured. *(BP 16.02, BP 16.06)*

Notes

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 work environment and delivered system. The Configuration Management process area allows the configuration to be traced through the hierarchy of requirements at any point in the configuration life cycle.

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, "configuration item" may be interpreted as "configuration component," "configuration unit," or any item identified for formal control.

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 change control, auditing, and inspection functions.

This process area applies not only to configuration management on projects, but also to configuration management on organization work products such as development and test environments, standards, procedures, and reuse libraries. This process area also covers the practices for performing configuration management functions, and is applicable to all work products placed under configuration management.

The terms "baseline" and "version control" are used in this process area to imply differing levels of formalization of control. "Baseline" is used to indicate rigorous control of identified items, which have formal release and verification activities associated with changes made to the items. "Version control" is used to indicate less formal control. Release of a version-controlled item may be as simple as an individual distributing an interim work product among coworkers for further work. Verification of a version-controlled item may be as simple as proofreading an interim work product before its distribution. Given this usage of the terms, the following considerations apply:

- The level of control should be planned for in the development of a CM strategy (BP 16.01), and used as a consideration in the identification of configuration items and controlled work products (BP 16.02). See the notes in these base practices for additional guidance.
- The use of "baseline" and "version control" to distinguish between varying levels of control should not be construed as limiting the number of levels of formality to two. (One level of control, or more than two may be appropriate.)
- The level of control is made more formal as work products are shared with larger groups, or as items are transitioned from a development environment to an operational one.
- The use of the term "version control" to indicate less formal control should not be confused with the release of software versions for customer use; release of software versions for operational use is typically brought about by the most formal level of control identified in the CM strategy.

Relationships between this PA and other PAs

This process area supports all other process areas in controlling work products, and its practices are usually accomplished through collaborative activities, such as those provided by the practices of Integrated Teaming (PA 14). Traceability is established as part of the practices in the Requirements process area (PA 02). The development of plans and work breakdown structures, as described in Project Management (PA 11), may be

useful for determining configuration items. Preliminary configuration management requirements are established in the Requirements process area (PA 02).

When the practices of this process area are used to manage requirements, changes to those requirements need to be iterated through the Needs process area (PA 01) to communicate the impact of changes to the customer or their surrogate. In this process area, information is available about the method for analyzing the impact of proposed changes.

Information Management (PA 17) and Configuration Management process areas are interrelated, but differ in a number of ways. Configuration Management emphasizes informal and formal control of selected work products and environments. Information Management is concerned with the identification, protection, and continued availability of all information that may be needed by or that is generated by project or enterprise elements. Items from information management repositories may be placed under configuration management, as the need arises. The practices of Information Management apply to the storage and retrieval of Configuration Management Items. Configuration Management and Information Management may use the same or separate repositories.

Base practices list

BP 16.01 **Establish a configuration management strategy**: Establish roles, responsibilities, and methods for the application of CM activities.

BP 16.02 **Identify and baseline configuration items and interim work products:** Identify configuration items, interim work products, and work environment items that will be baselined or placed under version control, and baseline them.

BP 16.03 **Establish and maintain a repository for work product baselines:** Establish and maintain a repository to house work product baselines.

BP 16.04 **Control changes:** Control changes to baselined work products through tracking, recording, review, and approval processes throughout the life cycle.

BP 16.05 **Record and report configuration status:** Record and report change information about the baselined configuration items.

BP 16.06 **Conduct configuration audits and inspections:** Conduct configuration audits and inspections to verify integrity of the baselines and check the work products for compliance with the baselines.

BP 16.01 Establish a configuration management strategy

Establish roles, responsibilities, and methods for the application of CM activities.

Description
Configuration management planning and management activities identify a strategy for the application of configuration management that balances cost with program needs.

A configuration management strategy:
- defines roles and responsibilities for all CM activities
- defines resources required to conduct CM activities
- defines how CM will be applied to individual work products
- defines how tools are to be selected and implemented
- identifies CM policy that applies to work products that will be managed

Identification of roles and responsibilities includes authority for formal establishment and changes to baselines, and may include the identification of delegated authority to maintain version control of specified items. A mechanism for representing the interests of stakeholders shall also be specified.

A definition of how CM will be applied to items that will be managed will identify:
- the level of detail at which the configuration items are identified
- when the configuration items are placed under configuration control
- the level of formalization required for different types of work products

A means to modify the strategy when necessary must also be identified.

Typical Work Products
- Configuration Control Board Charter
- documented CM application strategy for individual configuration items
- CM policy statement
- strategy for tool selection, implementation, and use

Notes
CM Plans may be established to address either individual products, or groups of products identified as a program that are managed by the same organization. CM plans identify the criteria for or events for starting configuration control of identified products. They also address the events around which CM audits and inspections are planned. They are developed from information about the anticipated acquisition or development, testing, maintenance, and operations strategies of the work products.

Example criteria for selecting configuration items at the appropriate work product level:

- the need to maintain interfaces at a manageable level
- unique user or maintainer requirements such as field replaceable units
- new versus modified design
- expected rate of change

These criteria will affect the level of visibility into the effort.

Example criteria for determining when to place work products under configuration management:

- portion of the development life cycle that the project is in
- if system element is ready for test
- degree of formalization selected
- cost and schedule limitations
- customer requirements

Example criteria for selecting a configuration management process:

- stage of the life cycle
- impact of change in system on other work products
- impact of change in system on procured or subcontracted work products including COTS/NDI
- impact system changes on program schedule and funding
- requirements management process

Each criterion listed above will have an impact on the cost.

Identification of CM policy may be an invocation of higher-level CM policy. If such policy does not exist or does not apply to the items that will be managed, policy specific to these items must be established.

BP 16.02 Identify and baseline configuration items and interim work products

Identify configuration items, interim work products, and work environment items that will be baselined or placed under version control, and baseline them.

Description
Configuration identification is the selection of work products that comprise the system, product or service to be baselined. Work products under configuration management will include all system and software specifications, work products, and data that define configuration items. Test configurations are also baselined. Other documents, such as test results, may also be included depending on their criticality to defining the product. This base practice also includes establishment of initial baselines.

During the early stages of the life cycle, prior to baselining configuration items, identify work products to be controlled. Configuration items in a dynamic (or developer's) system are under either (the developer's) formal change control or version control. Identify all work products including those under the sole control of the work product owner (which may be an individual, a development group, or a team). Once a baseline is established, work products will be identified and these configuration items will be placed under formal configuration management.

A configuration item is one or more work products that are baselined together. The selection of work products for configuration management from all interim work products should be based on criteria established in the selected configuration management infrastructure. Configuration items should be selected at a level that benefits all stakeholders, but that does not place an unreasonable administrative burden on the developers.

Identify product or service work products that are configuration items. Distinguish them by unique identifiers or markings, according to relevant standards and product sector conventions, such that the configured items are unambiguously traceable to their specifications or equivalent documented descriptions. For each configuration item and its versions, identify the work products, documentation that establishes the baseline, version references; and other identification details.

Baselining is the act of placing an item under change control such that all changes are made through a defined process. The baseline configuration defines the characteristics of an item during its life cycle. A "baseline" describes one or more configuration items and the associated entities of which it is composed.

The baselines for each configuration item should be identified when it is placed under configuration control. Baselines provide a stable basis for the continuing evolution of configuration items. 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.

Baselines may also be established at different times internally and with a customer. An internal baseline of drawings might be established before fabrication; the customer baseline occurring starts at delivery. Establishment of baselines is encouraged in the earliest stages of the life cycle.

Optimization includes defining the correct items to manage and establishing the correct timing for baselines. Baselining too soon (before maturity starts) increases the administrative costs of changes, and baselining too late increases the risk of undesired changes.

The baselining activity associated with this base practice involves assembling the necessary documentation that describe configuration items, and submitting it to the configuration control board. This is done in accordance with procedures established in BP 16.04. This can be done iteratively as the documentation describing the configuration item becomes more detailed later on in the lifecycle.

Typical Work Products

- baselined work product configuration
- identified configuration items
  - baselined configuration
  - interface documentation
  - traceability matrix
  - specification trees
  - drawing trees
  - release documents
  - decision database
  - process-related documentation (e.g., plans, standards, or procedures)
  - system requirements
  - system design
  - software requirements
  - software code units
  - hardware items
  - test procedures
  - test configurations of test equipment, tools, and scripts
  - software/system build for the software/system test activity
  - software/system build for delivery to customer or end user
  - compilers
  - support tools

Notes

Configuration items pertaining to requirements could vary from individual requirements to groupings of requirements documents.

Configuration items for a system that has requirements on field replacement should have an identified configuration item at the field-replaceable unit level. The owner responsible for each configuration item is identified.

Although the responsibility for technical content of work products remains with the engineering technical task, the configuration management identification function shares responsibility for proper structure of specification trees, level of documentation, and general content and format of documentation.

Customer property may be identified as a configuration item.

Additional Practice Guidance

- Identify work products that define the product.
- Identify work products from all Process Areas that require configuration management.
- Identify all deliverable and non-deliverable data.

BP 16.03 Establish and maintain a repository for work product baselines

Establish and maintain a repository to house work product baselines.

Description
This practice involves establishing and maintaining a repository of information comprised of work product baselines as they are developed. The repository provides for storage and retrieval of configuration items/records, sharing and transfer of configuration items/records between affected groups and individuals, and the production and dissemination of CM reports. The release of configuration items/records from the repository is controlled. Product builds and releases are authorized by the controlling mechanism and are created only from the configuration items/records in the approved baseline library.

Procedures for operating the repository should define the repository location(s), tools or environments used to store baselined information electronically, storage media, check-in and check-out procedures, and authorities. Means to distinguish among various versions of the same configuration item must be in place. Procedures must define how data is archived and retrieved.

Operation of the repository should also include periodic auditing against current status accounting information to ensure that the repositories contain all currently baselined information.

Establishment of the repository should incorporate security measures appropriate for the information being stored.

Typical Work Products
- roles, responsibilities, and authorities specific to the operation of the repository
- procedures for operation of the repository, including stakeholder access procedures
- physical and/or electronic repository(ies) that contain all baselined information
- an index or catalog that identifies the current contents of the repository(ies)

Notes
For software, the baseline repository also allows multiple control levels of software configuration management. One example of a situation requiring multiple levels of control is the differences in the levels of control needed at different times in the life cycle (e.g., tighter control as the product matures).

Any repositories established for this process area may also be part of any repositories identified to satisfy the requirements of PA 17, Information Management.

BP 16.04 Control changes

Control changes to the baselined work products through tracking, recording, review, and approval processes throughout the life cycle.

Description

Control is maintained over the configuration of the baselined work product. This includes tracking the configuration of each configuration item, approving a new configuration, if necessary, and updating the baseline. Change control authority is established to provide coordinated review, evaluation and disposition of documented and justified change proposals to configured items. Design and/or development changes are identified, documented and controlled. This includes analysis of the effect of the changes on constituent parts and delivered products. The changes are verified and validated, as appropriate, and approved before implementation. The results of the review of changes and subsequent follow-up actions are documented.

Change requests and problem reports for all configuration items should be initiated, recorded, reviewed, approved, and tracked. Change requests address not only new or changed requirements, but also failures and defects in the work products. Changes are analyzed to determine the impact that the change will have on the work product, schedule, and cost. If, based upon analysis, the proposed change to the work product is accepted, a schedule is identified for incorporating the change into the work product and other affected areas.

Changed configuration items are released after review and formal approval of configuration changes by the controlling mechanism. Changes are not official until they are released.

Different levels of control are appropriate for different work products and for different points in time. Configuration items in a dynamic (or developer's) system are under 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). For some work products, it may be sufficient to maintain version control. Version control is usually under the sole control of the work product owner (which may be an individual, a development group, or a team).

Control of changes includes identification and recording of change requests; analysis and evaluation of the changes; approval or disapproval of the request; and implementation, verification, and release of the modified configuration item. An audit trail should exist for each modification, the reason for the modification, and authorization of the modification.

Optimization of change control includes the selection of the level of formal control to be implemented. A balance is needed between the cost of formal control and the risk of uncontrolled changes.

Records are controlled to provide evidence of conformance to requirements and of effective operation of the configuration management system. A documented procedure

ensures identification, storage, retrieval, protection, retention time, and disposition of records.

Typical Work Products

- modified work-product baselines
- change requests
- problem reports
- specification change notices
- document change notices
- decision records
- deviations and variances
- waivers
- revision history of configuration items
- archives baseline

Notes

Change control mechanisms can be tailored to categories of changes.

Changes are analyzed through a process that ensures they are consistent with all the technical and project requirements. Changes are analyzed for their impact beyond the immediate program or contract requirements. Changes to an item used in multiple products can resolve an immediate issue while causing a problem in other applications.

Schedule and conduct the change-request review with the 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.

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.

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. 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. Changed configuration items are released after review and approval of configuration changes. Changes are not official until they are released.

Additional Practice Guidance

- Changes to established baselines are recorded, reviewed, approved, controlled, and verified as incorporated.
- Initiate and record change requests in the change request system.
- Analyze the impact of proposed changes and fixes.
- Review and get agreement with those affected by change requests that will be addressed in the next baseline.
- Track the status of change requests to closure.
- Control changes to configuration items throughout the life cycle.
- Obtain appropriate authorization before changed configuration items are entered into the configuration management system.
- Check in and check out configuration items from the configuration management system for incorporation of changes in a manner that maintains the integrity of the configuration items.
- Perform reviews to ensure that changes have not caused unintended effects on the baselines, i.e., that the changes have not compromised safety and/or security of the system.
- Record changes and the reasons for the changes.
- Formally control release of products from the baseline library.

BP 16.05 Record and report configuration status

Record and report change information to the baselined configuration items.

Description

Status accounting provides the traceability of configuration identification and facilitates the effective implementation of approved changes. The status activity will identify all configuration item requirements, their individual implementation schedules, and the performance history against those schedules. Information may identify originators of each work product, customer response dates, disposition, security classification, etc. The status of configuration items is communicated to those that need it.

The status reports should include information on when accepted changes to configuration items will be processed, and the associated work products that are affected by the change. Access to configuration data and status should be provided to all stakeholders.

Manage the recording, retrieval and consolidation of the current configuration status and all preceding configurations to confirm information correctness, timeliness, integrity and security. Consolidate the evolving configuration state(s) of configuration items to form documented baselines at designated times or under defined circumstances. Maintain configuration records through the life cycle. Record the steps of the project's configuration, the rationale for the baseline, and associated authorizations in configuration baseline data.

Prepare and manage records and status reports that show the status and history of controlled configuration items including baselines. Status reports should include the number of changes for a project, latest configuration item versions, release identifiers, the number of releases, and comparisons of releases.

Typical Work Products

- status reports
- configuration control board meeting minutes
- change request summary and status, including implementation status
- trouble report summary and status (including fixes)
- summary of changes made to baselines
- revision history of configuration items
- baseline status
- baseline audit results
- as built list or records
- release notes
- revision history of configuration items
- change log

Notes

Examples of activities for communicating configuration status:

- provide access to authorized users
- make baseline copies readily available to authorized users

Additional Practice Guidance

- Status of configuration data, changes, and access information is recorded, tracked, and communicated to affected groups.
- Record configuration management actions in sufficient detail so the content and status of each configuration item is known and previous versions can be recovered.
- Ensure affected individuals and groups have access to and knowledge of the configuration status of the configuration items.
- Specify the latest version of the baseline.
- Identify the version of configuration items that constitute a particular baseline.
- Describe the differences between successive baselines.
- Revise the status and history (i.e., changes and other actions) of each configuration item as necessary.
- Track changes from initiation, review, adjudication, and implementation in each instance of the affected configuration item.

BP 16.06 Conduct configuration audits and inspections

Conduct configuration audits and inspections to verify integrity of the baselines and check the work products for compliance with the baselines.

Description
Configuration audits and inspections are conducted to verify that a configuration item has achieved its specified performance level (functional), and that the design documentation matches the as-built work product (physical). Configuration audits and inspections also serve as a prerequisite for establishing the product baseline configuration to be used for production and acceptance purposes. Audits and inspections ensure the quality and correctness of the configuration information and, where necessary, corrective actions are taken to recover information integrity.

Configuration audits are performed to maintain the integrity of the configuration baselines. Audit configuration management activities and processes to confirm that the resulting baselines and documentation are accurate and record the audit results as appropriate. Inspections are performed during the early stages of development on the repositories of interim work products that are placed under version control.

Configuration audits involve checking an item for compliance with its configuration baseline and the accuracy of the baseline documentation. Configuration audits validate that the developed item fulfills its technical requirements, e.g., in a Functional Configuration Audit (FCA), and that the product configuration is properly identified, e.g., in a Physical Configuration Audit (PCA). This is accomplished by comparing the configuration item with its technical documentation and the status reports.

Typical Work Products
- baseline documentation
- audit procedures
- audit results
- action items

Notes
Audit, as used in this PA, is an examination of work products to assess compliance with specifications, standards, contractual agreements, or other criteria.

Audits should confirm both the accuracy and currency (incorporation of changes, etc.) of each level of baseline (requirements/design/product) and the consistency between levels (requirements match the design and the design matches the product baseline).

Audits are planned to take into consideration the status and importance of the activities and areas to be audited as well as the results of previous audits. The audit scope, frequency and methodologies are defined. Personnel other than those who performed the activity being audited conduct audits. A documented procedure includes the responsibilities and requirements for conducting audits, ensuring their independence, and

recording results and reporting to management. Management takes timely corrective action on deficiencies found during the audit. Follow-up actions include the verification of the implementation of corrective actions, and the reporting of verification results.

If during an audit any customer property is found to be damaged or lost, this should be reported to the customer.

Additional Practice Guidance

- Periodically audit configuration management activities and processes to confirm that the resulting baselines and documentation are accurate. Record audit results.
- Assess the integrity of the baselines; check the work products for compliance.
- Verify that the configuration records correctly identify the configuration of the configuration items.
- Review the structure and integrity of the items in the configuration management system.
- Verify the completeness and correctness of the items in the configuration management system.
- Completeness and correctness of the content are based on the requirements as stated in the plan and the disposition of approved change requests.
- Verify compliance with applicable configuration management standards and procedures.
- Track action items from the audit to closure.

PA 17: Information Management

Process Area Summary

Purpose
The purpose of Information Management is to make relevant, and timely information available to those who need it during and after the lifetime of products and services.

Major points addressed
Information management processes collect, store, protect, retrieve, disseminate and dispose of information needed to achieve project, organization, and enterprise goals, according to established and maintained requirements and strategy. Information management provides an infrastructure and resource that supports sharing of information and knowledge and provides authorized users with timely access to needed information. Information is protected from damage, loss, unauthorized access, and compromise of intellectual property rights.

Goals
1. An infrastructure is established and maintained to provide the mechanisms and media needed to support information management at project, organization, and enterprise levels. *(BP 17.02)*
2. Information is managed in accordance with established requirements and strategy. *(BP 17.01, BP 17.06)*
3. Information is stored and protected from loss, damage, and unwarranted access. *(BP 17.03, BP 17.05)*
4. Timely access to information is available to those that need it. *(BP 17.04)*

Notes
Information, as used in this process area, includes the various forms of hardcopy and softcopy documentation needed by projects, organizations, and the enterprise. Typical information management categories include customer communications, customer and other external documentation and reference material, requirement issues, metrics, status reports, architecture and design notes, design reference material, meeting minutes, etc. Information may take any form (e.g., reports, manuals, notebooks, charts, drawings, data bases, spreadsheets, specifications, files, e-mails, audio, video, or correspondence), and may exist in any medium (e.g., printed, drawings on various materials, photographs, electronic, or multi-media). Information may be deliverable (e.g., items identified by a project's data requirements), or non-deliverable (e.g., informal information, tacit knowledge, expertise, studies and analysis, internal meeting minutes, internal design review documentation, lessons learned, and action items). The availability of information to staff when it is needed is a crucial aspect of information management. Information Management resources and capabilities support knowledge sharing.

Relationships between this PA and other PAs

All process areas rely on the practices of Information Management to preserve and maintain access to information. Project Management (PA 11) uses the practices of Information Management to identify information items and categories of information to be managed. Information items are created by appropriate process areas and indicated in the Typical Work Product paragraphs of the process areas. Quality Assurance and Management (PA 15) ensures the integrity, authenticity, reliability, and accuracy of selected information products.

Work products, reference material, and notes from all process areas are collected stored and managed by Information Management. Information Management makes needed information available for increasing an organization's capacity for Innovation (PA 23). It enables the timely sharing of vital information horizontally and vertically among organizations and team members engaged in Integrated Teaming (PA 14). Information Management protects and makes available process documentation to, and uses information from, the organization's process asset library, described in Process Definition (PA 20).

Information Management and Configuration Management (PA 16) process areas are interrelated, but differ in a number of ways. Configuration Management emphasizes informal and formal control for selected work products. Information Management is concerned with the identification, protection, and continued availability of all information that may be needed by, or generated by, projects or enterprise elements. Items from the information management repositories may be placed under configuration management, as the need arises. The practices of Information Management apply to the storage and retrieval of Configuration Management Items. Configuration Management and Information Management may use the same or separate repositories.

Base practices list

BP 17.01 **Establish information management strategy:** Establish and maintain a strategy and requirements for information management.

BP 17.02 **Establish information management capability:** Establish an infrastructure for information management including repository, tools, equipment, and procedures.

BP 17.03 **Store information:** Collect, receive, and store information according to established strategy and procedures.

BP 17.04 **Share information:** Disseminate or provide timely access to information to those that need it.

BP 17.05 **Protect information:** Protect information from loss, damage, or unwarranted access.

BP 17.06 **Establish information standards:** Establish requirements and standards for content and format of selected information items.

BP 17.01 Establish information management strategy

Establish and maintain a strategy and requirements for information management.

Description
Define a strategy for management of information and the required information items and categories of information to be acquired, stored, protected, and available to staff, for projects, the organization, and the enterprise. Communicate the required categories of information to be captured and update the categories as needs arise. Solicit specific information needs for the acquisition of external or reference material. Establish information access and security requirements according to project and organizational needs. Establish time limits for retention and destruction of information. Define requirements for visibility and retrieval of information.

Typical Work Products
- categories of information required to be placed in the information repository
- specific information items to be placed in the information repository
- information access and security requirements
- typical categories of information to be managed
- customer and supplier communications
  - internal and external project communications
  - requirement and design issues
  - meeting minutes
  - project related reference material
  - design notes
  - lessons learned (from all projects)
  - concept papers
  - new technology items

Notes
Unlike Configuration Management, the individual information items to be managed cannot always be determined in advance. Frequently, important information items are generated without prior knowledge (e.g., a letter from a customer or supplier, outsourcing rationale, specific emergent risk items, etc.). The initial list of categories of information items to be managed may be a best estimate or based on historical lists of categories or organizational standard categories (e.g., all communications from customers and suppliers, rationale for rejection of alternative designs).

Information designated for collection and storage should consist of deliverable and non-deliverable documentation, as well as historical or background information that would be useful to future projects, and to the organization's corporate knowledge base. For example, information associated with a project's product development, such as initial versions of product or service specifications, drawings, configuration control records, and potential requirements should be collected and stored.
As development of projects and services evolves, appropriate information items will be placed under configuration management. The standards and criteria used to develop the

product or deliver the service, the market analyses conducted to select the product or design, the design development model and environment, and the rationale for decisions made during the product's evolution should all be considered for corporate retention. Process asset libraries should also be included in the managed information.

Additional Practical Guidance

- Establish templates and author guidelines for selected documents.
- Solicit staff for the information items and types needed to perform their jobs.
- Establish a data base of internal and external experts.

BP 17.02 Establish information management capability

Establish an infrastructure for information management including repository, tools, equipment, and procedures.

Description
Establish the hardware, software, procedures, and personnel resources to store, protect, and retrieve information efficiently. Provide common information management archival and retrieval capabilities throughout the organization. Archive information efficiently based on common characteristics (e.g., key words, topics, contract number, etc.). Provide information storage, protection, and access in accordance with the information strategy and requirements.

Typical Work Products
- information databases
- electronic libraries
- web-based repositories
- raw data repositories of the development tools such as CASE tools, databases, file systems, and other tool repositories
- information library
- web-based database
- information capture, storage, protection, and access procedures
- external library and data bases subscriptions

Notes
An information management capability should include a full range of technologies appropriate for various information media. Storage media considerations include selecting media according to the required storage time (e.g., consider whether equipment will be available in the future for reading the media). While as much information as practical should be stored electronically for ease of management, many sources may only be available in traditional hardcopy. Technology advances in electronic search engines lessen the need for sophisticated organization and indexing. Storage capabilities may be needed for electronic, photographic, paper, or film and the storage times may range from short-term to indefinite.

BP 17.03 Store information

Collect, receive, and store information according to established strategy and procedures.

Description

Capture and store the required information according to established requirements, mechanisms and procedures.Information storage records identify the source of each information item, the date stored, access or security controls, and the date for destruction. Retaining information beyond its useful lifetime may result in unnecessary storage cost and pose privacy/security risks. Record and maintain the status of program data, and update and publish the status of the program data. Information items should be reviewed periodically for currency, relevancy, and validity and the results used to maintain the repository contents.

Typical Work Products

- data accession list
- data management plan
- status reports
- information catalog
- catalog updates
- library index

Notes

Information can be stored either informally (without indexing) or formally (e.g., based on characteristics (e.g., key words, topics, contract number, etc.) for ease of retrieval as required by the information management strategy and requirements. Managed information should be transferred to configuration management as needs arise.

The information assets of an organization are not confined to formal or configuration managed documents; they vary from the highly ordered to the ephemeral, and some of the most valuable information may be hidden in informal sources such as reports, office memos, study reports, project documents, photographs, etc.

BP 17.04 Share information

Disseminate or provide timely access to information to those that need it.

Description
Disseminate information according to the information strategy and project requirements. Provide efficient and timely information retrieval to meet the needs of authorized users.

Typical Work Products
- mechanism for information retrieval, reproduction, and distribution
- information databases with electronic search capability
- information base or library indexes

Notes
The latest technology, such as electronic indexes and search engines, should be considered for electronically stored information. Software tools and information processing algorithms may be useful in finding and grouping similar information.

Additional Practice Guidance
- Provide to those that retrieve information, visibility of others who have retrieved the same or similar information.

BP 17.05 Protect information

Protect information form loss, damage, or unwarranted access.

Description
Establish information access control mechanisms, in accordance with the information management requirements, that allow only appropriate personnel to access information. Conduct information management activities in accordance with laws on intellectual property rights. Provide for backup storage to protect information from natural disasters (e.g., fire and flood). Assess the validity of selected information and protect validated information from potentially damaging information.

Typical Work Products
- privacy requirements and controls
- access requirements by information category and user level
- security requirements by information category and user level
- security procedures
- list of authorized users for access
- procedures for Internet information downloading
- backup storage locations

Notes
Access controls should provide appropriate protection for information that is proprietary, politically sensitive, financially sensitive, subject to export control or meets requirements for national security protection. Offsite storage should be considered for backup of information repositories. Information should be protected from potentially damaging information such as software viruses and misinformation.

BP 17.06 Establish information standards.

Establish requirements and standards for content and format of selected internally produced information items.

Description
Establish the format and content requirements for selected internally produced information items. Documentation standards encourage uniformity and quality for appropriate documents, such as plans and specifications.

Typical Work Products
- author instructions and templates for plans and specifications
- data item descriptions
- data development standards
- document quality criteria

Notes
Documentation standards typically include, in addition to the primary content: administrative items such as title, date, identifier, version history, author(s), reviewer, authorizer, outline of contents, purpose, and distribution list.

PA 18: Measurement and Analysis

Process Area Summary

Purpose
The purpose of Measurement and Analysis is to collect and analyze data related to processes and resulting products and services to provide quantitative insight into performance relative to goals.

Major points addressed
Measurement and analysis involves developing a quantitative understanding of processes, products, and services in the context of business goals, analyzing performance in these areas and providing information on which to base improvements. Measurements, when established throughout the product or service life cycle, provide objective insight into the process and its outcome. The integration of measurement and analysis into processes, products, and services supports the ability to plan, estimate, and track actual performance against established plans and objectives, as well as identify and resolve related issues. Measurement begins by defining the measures needed to support goals. Measurement data relative to goals are then collected, stored, and analyzed and results are reported to appropriate stakeholders to support effective decision making.

Goals
1. Measures related to goals, objectives and major issues are established. *(BP 18.01)*
2. Measurement data are collected, analyzed, and results are reported. *(BP 18.02, BP 18.04, BP 18.05)*
3. Measurement data and results are stored for use. *(BP 18.03)*

Notes
Collecting and analyzing key measurement data provide information needed to manage issues and goals and form a basis for analyzing process performance. Measurements are composed of process and product data that quantify the performance and effectiveness of both the processes and products. Performance measurements are characterized by both process and work product data (e.g., effort, cycle time, defect removal efficiency, productivity, and service response time) and product measures (e.g., reliability, and defect density).

Measures are used in establishing performance objectives and their values can constitute a baseline against which actual performance can be compared. This information is used to manage quantitatively. Measurement provides performance results which support decisions and provide an objective basis for communication.

Some general categories of measures:

- schedule and progress
- resources and cost
- product size and stability
- process performance
- product/service quality
- contractor performance
- technology effectiveness

Some definitions:

- *Measure:* Property, attribute, scale, or unit that is used for quantification.
- *Base measure:* A distinct property or characteristic of an entity and the method for quantifying it.
- *Derived measure:* A function of two or more base measures.
- *Indicator:* An estimate or evaluation of specified attributes derived from a model with respect to defined information needs; combination of measures usually presented as a graph, chart, or table.
- *Value:* A numerical or categorical result assigned to a base measure, derived measure, or indicator.
- *Measurement:* The process of assigning quantitative values to measures or properties according to some defined criteria. This process can be based on estimation or direct measurement. Also, a value resulting from performing the measurement process.
- *Model:* An algorithm or calculation combining one or more base and/or derived measures with associated decision criteria.
- *Analysis:* The use of data to identify problems, access problem impact, project an outcome, or evaluate alternatives related to issues.

Relationships between this PA and other PAs

Measurement and Analysis (PA 18) is a supporting process area that relates to any process area within the model.

This PA specifically supports Integrated Enterprise Management (PA 00), Project Management (PA 11), Evaluation (PA 08), Quality Assurance and Management (PA 15), and the internal team process performance of Integrated Teaming (PA 14). It establishes the basis of the measurement data repository addressed in Process Definition (PA 20) and managed using Information Management (PA 17). The practices of the Measurement and Analysis process area support the Needs process area (PA 01) through measurement of customer satisfaction with products and services. Actions as a result of Measurement and Analysis are seen in Integrated Enterprise Management (PA 00), Project Management (PA 11) and Quality Assurance and Management (PA 15). If solicitation of contractors/subcontractors is required, measurement is addressed in the solicitation request and response (See PA 05, Outsourcing). Risk Management (PA 13) provides the mechanism to identify issues to be measured.

Base practices list

BP 18.01 **Establish measures based on goals:** Establish measurable objectives from issues and goals and identify the specific measures that will provide the basis for performance analysis.

BP 18.02 **Collect relevant measurement data:** Collect and verify measurement data and generate results.

BP 18.03 **Store data and results:** Store measurement data and results in a repository.

BP 18.04 **Analyze measurement data:** Analyze data to determine performance against goals.

BP 18.05 **Communicate results:** Report results of measurement and analysis to all affected stakeholders.

BP 18.01 Establish measures based on goals

Establish measurable objectives from issues and goals and identify the specific measures that will provide the basis for performance analysis.

Description
Establishing measurable objectives based on business goals includes the identification, prioritization, and documentation of process, product, and service issues. Specific measures are selected that provide insight into business goals and issues.

Typical Work Products
- documented measurement objectives
- prioritized issues based on risks and needs
- list of candidate measures
- definitions for the selected performance measures
- measurement plan

Notes
Program and organizational process objectives, issues, business goals, and information needs drive the measurement requirements. Measurement helps achieve project objectives, meet organizational process improvement goals, identify and track risks, and recognize issues and problems. Process, product and service objectives and issues should be identified and prioritized early. If solicitation of contractors/subcontractors is required the measurement program should be addressed in the solicitation.

The resulting profile of objectives, issues, and business goals is used to select and specify the required measures. This profile and the associated measurement requirements, are evaluated and revised periodically and should be specified across the life cycle. To do this in a cost-effective manner, only those measures that are necessary to provide the required performance or quality insight should be implemented. One rule of thumb is to use three to five measures at one time on a process and its product or service. It is important to note that measurements that are implemented reflect the technical and management characteristics of the process activities.

A profile of issues may be derived from the following sources:
- risk analysis
- program constraints and objectives
- use of new technologies
- product acceptance criteria
- external requirements
- experience

A measurement program can ensure that measures that are implemented reflect the technical and management characteristics of the process activities.

BP 18.02 Collect relevant measurement data

Collect and verify measurement data and generate results.

Description
Measurement data are collected and verified from relevant sources. The verified data are used to generate values for identified measures. Measures are combined to produce newly calculated values as required.

Typical Work Products
- measurement data
- automated data collection mechanisms (such as templates and forms)
- measurement data definitions
- documented data collection procedure
- data collection tools

Notes
Collecting, verifying, assigning values, and understanding the data are crucial in the measurement and analysis process. The collected data should closely reflect the nature of the product and process. The frequency of data collection and the points of collection within the process as well as how the data is collected, stored, and made available for analysis, are considerations in data collection. The data collection process is integrated with other normal work processes and those responsible for collecting data are identified. The data collection mechanism can be manual or automated forms or templates. Automatic collection should be supported when feasible.

Data are obtained from existing databases, records, and repositories and reviewed for appropriateness with users. Data are collected as necessary for previously used as well as newly specified base measures. Existing data are gathered from project records or from elsewhere in the organization. Base and derived measurement data sets are collected and the data are generated for derived measures. Data integrity checks, as close to the source of the data as possible, are performed. Because 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. Integrity checks can be performed by scans for missing data, identification for out of bounds data values, and unusual patterns and correlation across measures.

Data verification ensures that the data provided relate to pertinent program events and allow for consistency of data, such as units of measures across sources or organizations. Procedures are reviewed for their appropriateness and feasibility with those who supply and collect data, and are revised as necessary. Decisions regarding priorities may need to be readdressed based on the importance of the measures and the effort required to obtain the data.

Data verification may be performed by inspecting against a checklist. The checklist should be constructed to verify that missing data is minimal, and that the values make

sense. Examples of the latter include checking that a defect classification is valid, or that the size of a component is not significantly greater than all previously entered components. In case of anomalies, the data provider(s) should be consulted and corrections to the raw data made where necessary.

Data definitions developed during the measurement selection process and documented in the measurement plan define the detailed specifications for each data item to be collected. They describe what raw data need to be collected, when it is available, what format it will be in, what software tool or other source it will come from, etc. Data definitions are used to confirm that the data collected matches the data specified in the measurement plan.

Measurement data may be either base or derived data. Data for base measures are obtained by using raw data. Data for derived measures are obtained by combining two or more base measures. Derived measures are generally expressed as ratios, composites, and indexes.

Data sources:

- key performance measures
  - schedule and progress
  - resources and cost
  - size and stability
- performance results
  - technical adequacy
- evaluation of strategic goals
- project evaluation

Examples of classes of commonly used measures include the following:

- project evaluation
- 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, defect density)
- peer review coverage
- test or verification coverage

BP 18.03 Store data and results

Store measurement data and results in a repository

Description
Data to be analyzed must be selected and stored to ensure that data are available and accessible for future use and the establishment of performance baselines. Appropriate stakeholders are advised of availability of the stored data.

Typical Work Products
- project data
- measurement plans
- analysis reports
- historic database or repository of measurement data
- documented storage procedures
- process database

Notes
Storing quantitative process, product, and service data provides information for future estimation and cost effective decisions. Access to sets of data, measurement plans, analysis reports and presentations provide information for the achievement of business goals including accuracy of future projections and a basis for corrective actions. Storing measurement data enables the establishment of an historical repository. This information can be used to provide the context for interpretation of data, measurement criteria, and analysis results.

Procedures are in place describing how data will be stored in an accessible manner for analysis, maintained, and saved for reanalysis or documentation purposes. The procedures should address who is responsible for storing, maintaining, updating, retrieval and security. It is important that stakeholders are aware of the repository and its contents; however, procedures are in place to prevent unauthorized usage. Ways to prevent inappropriate use of data and related information include controlling access to data and educating people on the appropriate use of data project data.

Examples of inappropriate use:
- 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.

Information typically stored within a repository:

- measurement plans
- specific measures
- sets of data that have been collected
- analysis reports and presentations

The stored information contains information or directs users to information pertinent to understand and interpret the measures and assess them for reasonableness and applicability.

Data sets for derived measures typically can be recalculated and need not be stored. It may be appropriate to store summaries based on derived measures such as charts, tables of results, or report interpretations. Interim analysis results need not be stored separately if they can be efficiently reconstructed. When data are shared across projects, the data may be entered into an organizational measurement repository.

BP 18.04 Analyze measurement data

Analyze data to determine performance against goals.

Description
Analyzing measurements involves data analysis, tracing to issues, looking at the project or organizational context, and identifying problems and new issues. It includes developing recommended actions/options and development of indicators.

Typical Work Products
- documented analysis procedure
- data analysis tools
- analysis results and draft reports
- control charts for statistical process, including:
  - c charts
  - np charts
  - p charts
  - u charts
  - X and mR charts
  - Z and R charts
  - X and s charts
- histograms for process analysis
- Pareto charts for problem analysis
- scatter diagrams for correlation and trend analysis
- indicators
- recommended actions/options

Notes
Verified low-level data is consolidated or combined into measurement indicators that provide insight into an issue or concept. All users of the measurement data should understand what the data represents. Measurement data should be at a low enough level of detail to allow for the isolation of problems and to support a high degree of analysis flexibility. This ensures that the data analyzed represent the associated processes and products, and project or organizational quality or process goal achievement. Measurement results should be interpreted in the context of other project and organizational information. Quantitative measurement results must be interpreted in the context of the project or organizational characteristics. The contextual information allows the user to identify the nature of the process issues and associated causes. It also helps to identify possible courses of action. This characteristic of the measurement program ensures that the quantitative measurement data are interpreted correctly.

There are many statistical techniques available for analyzing measurement data (e.g., statistical process control, confidence intervals, prediction intervals). Statistical process control is 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. It entails the establishment and use of statistical process control chart(s) (any or all of several types) to measure and identify out-of-control conditions in a process and take action to return the process to an in-control state.

Measurement should be integrated into the project management process throughout its life cycle. Although the measurements change with the changing processes, activities, and tasks, the measurement process continuously provides objective information to support project and organizational process objectives. In addition, measurement and analysis of process attributes early in the life cycle provides insight into future issues. This characteristic of measurement ensures that measurement becomes an integral part of the management and engineering activities.

Analysis should be based on the principle of non-partiality. This promotes an environment whereby analysis, and the conclusions that are reached, are not unduly influenced by other project factors and pressures. Analysis should encourage open dialogue among all affected parties and collaborative problem solving. This characteristic of the measurement program ensures that objective analysis is performed to meet the information needs of stakeholders.

An indicator is an estimate or evaluation of specified attributes derived from a model with respect to defined information needs. Indicators are the basis for analysis and decision-making. These are what should be presented to measurement users. An indicator is a measure or combination of measures that provide insight into an issue or concept. Indicators are generally presented as graphs or tables.

BP 18.05 Communicate results

Report results of measurement and analysis to all affected stakeholders.

Description
The results of the measurement and analysis activities are communicated to stakeholders in a timely and usable fashion to support decision making and assist in taking corrective action. Measurements provide stakeholders the ability to manage by quantitative facts.

Typical Work Products
- delivered reports and related analysis results
- control charts
- management metric "control panels"
- quality function deployment sets of matrices
- process team report appendices
- transmittal and guidance documents

Notes
Stakeholders, including intended users, sponsors, data analysts and data providers are to be apprised of measurement analysis and assisted in understanding analysis results. It is important to explain how and why measures were specified and how data was obtained, and how to interpret results based on the data analyses methods applied. It is also important that data providers and all users understand how the results of measurement analysis address their information needs.

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. Affected stakeholders include intended users, sponsors, data analysts, and data providers.

It may be necessary to assist measurement stakeholders in understanding results. Results are reported in a clear and concise manner and should be understandable and easily interpretable by the audience. Results are clearly tied to identified goals, information needs and objectives.

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.

The data presented should be made explicitly clear in how and why the base and derived measures were specified, how the data were obtained and how to interpret the results based on the data analysis methods. How the results of the measurement activities address measurement needs should be conveyed.

In order to accomplish this it may be necessary to discuss the results with the stakeholders, provide a transmittal memo giving background and explanation, briefing the users on results and provide training on the use and understanding of data.

Management by fact is a method that can be used. Measurements such as control charts may be used to communicate between process workers that operations are in or out of control, and indicate what to do if anomalous process behavior occurs.

Note that the measurement process itself should be measured and evaluated against specified evaluation criteria and conclusions regarding strengths and weaknesses made. Revision should be considered when the following events occur:

- 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 or changed

PA 19: Reserved for Future Use

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PA 20: Process Definition

Process Area Summary

Purpose
The purpose of Process Definition is to define and maintain a standard set of process assets that support organizational learning and improve process performance.

Major points addressed
Process Definition involves creating, coordinating, and managing the standard processes, that can be subsequently tailored to form the processes that will be followed in conducting the business of the project, organization, or enterprise.

This includes defining and maintaining life cycle process(es) that will meet business goals, as well as collecting, designing, developing, and documenting process assets. Assets include example processes, process fragments, process-related documentation, process descriptions, process architectures, process-tailoring rules and tools, and process measurements/data.

Goals
1. The set of standard processes is established and maintained. *(BP 20.01)*
2. Guides for tailoring the standard processes are established and maintained. *(BP 20.02)*
3. Goals, performance data, and other assets that support the processes are collected, maintained, and communicated. *(BP 20.03, BP 20.04)*

Notes
A "project" is an organizational element that produces an output or outcome. An "organization" is a unit within which many projects are managed as a whole. An organization shares a common top-level manager and common policies.

A "set of standard processes" is a typically a group of standard processes within an organization, or within a project, that share some common characteristics, but that are different enough in their domain of applicability to be considered as separate standard processes. The standard process definition typically applies to an organization, but may also apply to large projects, or projects that require standard processes that can be tailored for use within the project for a variety of circumstances.

This process area applies to the definition of all processes. If there is no standard process at the organizational level the project's processes become standard for that project.

Relationships between this PA and other PAs

This process area covers the initial activities required to collect, maintain, and standardize process assets for all process areas. The activities of this PA define the processes needed to achieve the enterprise vision and goals established by the activities of Integrated Enterprise Management (PA 00). Process improvement is covered in Process Improvement (PA 21). The quantitative understanding of the processes and process assets is covered in Measurement and Analysis (PA 18). The process asset library is maintained using the principles of Information Management (PA 17). New processes may be the result of activities described in Innovation (PA 23).

Base practices list

BP 20.01 **Establish standard processes:** Establish and maintain a set of standard processes.

BP 20.02 **Develop tailoring guidelines:** Establish and maintain tailoring guidelines for the set of standard processes and ensure their use.

BP 20.03 **Maintain process assets:** Collect and maintain process assets.

BP 20.04 **Coordinate and communicate process definition:** Coordinate and communicate process definition and improvement activities.

BP 20.01 Establish standard processes

Establish and maintain a set of standard processes.

Description
Develop a set of standard well-defined processes. The set of standard processes that defines a quality management system is developed using the facilities of the process asset library. The standard processes are placed in the process asset library. The standard process includes those lifecycle models approved for use within the organization or project. The standard process also defines uniform measurements, as identified using Measurement and Analysis (PA 18), for use across, and within, the projects. The rational for the standard process is documented. The process elements must be evaluated for consistency of inputs and outputs, redundant activities, and missing activities. Inconsistencies must be resolved between process elements and provision made for appropriate sequencing and verification features.

Where appropriate, the process improvements are installed on a pilot basis to determine their benefits and effectiveness before they are introduced into normal practice.

Typical Work Products
- organization's set of standard processes
- project's set of standard processes
- lifecycle model(s)
- rationale for selection of process and measures
- inputs to training
- inputs to process improvement
- Quality Management System
- process descriptions

Notes
A process description is a documented expression of a set of activities performed to achieve a given purpose. It 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.

Standard processes should include the interfaces to the other defined processes. In addition, references used to define the process (e.g., military standards, IEEE standards) should be cited and maintained.

To develop the standard process, all the process elements or activities of the process may be identified. The resulting process should be well defined.

Perform tradeoffs on proposed process improvements against estimated returns in cycle time, productivity, and quality. Use the techniques of Alternatives Analysis process area (PA 04).

A well-defined process includes:

- purpose
- readiness (entry) criteria
- inputs
- standards and procedures (activities)
- verification/validation mechanisms and criteria
  - success criteria
  - peer reviews
- measures
- outputs
- completion (exit) criteria
- a process owner or sponsor
- roles and responsibilities
- defined internal and external interfaces

BP 20.02 Develop tailoring guidelines

Establish and maintain tailoring guidelines for the set of standard processes and ensure their use.

Description
Define guidelines for tailoring the standard process for use in developing the defined process. Since the standard processes may not be suitable for every situation, guidelines for tailoring it are needed. The guidelines are designed to fit a variety of situations, while not allowing projects to bypass standards that must be followed or substantial and important practices prescribed by organizational policy. Tailoring reports are reviewed and approved by the appropriate individuals within the project and organization.

Typical Work Products
- tailoring guidelines for the set of standard processes
- tailoring reports
- tailored processes

Notes
Guidelines should enable the standard processes to be tailored to address variables such as the domain; the cost, schedule, and quality tradeoffs; the experience of the staff; the nature of the customer; the technical difficulty of activities, etc. Guidelines should state situations where tailoring is not allowed.

BP 20.03 Maintain process assets

Collect and maintain process assets.

Description
The experience information generated by the process definition activity, both at the organization and project levels, is stored (e.g., in a process asset library), made accessible to those who are involved in tailoring and process design efforts, and maintained so as to remain current. New process assets may be necessary during the development task and should be added to the process asset library. New processes, methods, and tools in limited use are monitored, evaluated, and, where appropriate, transferred to other parts of the organization or project. Project staff must be informed of the contents of the process asset library, have access to it, and be trained in its use.

Typical Work Products
- instructions for use of a process asset library
- design specifications for a process asset library
- process assets (see Notes)

Notes
The standard process assets are artifacts that relate to describing, implementing, and improving processes. These artifacts are assets because they are developed or acquired to meet the business objectives of the organization/project, and they represent investments that are expected to provide current and future business value.

The purpose of a process asset repository and library is to store and make available process assets that projects will find useful in defining the process for developing the system, developing their products, and delivering their services. The repository or library should contain examples of processes that have been defined, and the measurements of the process. When the standard process has been defined, it should be added to the process asset library, along with guidelines for projects to tailor the standard process when developing the defined process. The organizational process assets will also contain project assets.

Process assets typically include:

- the standard process
- the approved or recommended life cycles
- processes together with measurements collected during the execution of the processes
- guidelines and criteria for tailoring the standard process
- plans
- tailoring reports
- methods and tools
- selected reports
- process-related reference documentation
- measurements of the project
- lessons learned

BP20.04 Coordinate and communicate process definition

Coordinate and communicate process definition and improvement activities.

Description
Groups involved or affected by process definition and improvement activities or results are kept informed. The organization's policy is communicated to the project personnel. The information may be at project or organization-wide scope. This information is disseminated to affected groups and stored in the process asset library. New processes are deployed to the projects for their use as appropriate.

Typical Work Products
- communication strategy for process definition and implementation
- reports, analyses, and advisories on activities
- electronic newsgroups and Web-based communications
- database of process assets
- decision memoranda
- training and information seminars
- process improvement plan

Notes
Definition and improvement both must be kept visible so a communications strategy is needed. A strategy includes:
- an information needs analysis
- specification and allocation of the information requirements to information products
- dissemination mechanisms, including training
- feedback mechanisms that monitor the effectiveness of the communications against their specified objectives

PA 21: Process Improvement

Process Area Summary

Purpose
The purpose of Process Improvement is to continuously improve the effectiveness and efficiency of the project and/or organization's processes so that its business is conducted more efficiently and effectively.

Major points addressed
Process Improvement involves understanding processes within the context of business goals, analyzing the performance of processes, and explicitly planning and deploying improvements to those processes through continuous process improvement. Quantitative objectives for the organization's set of processes and the projects' processes are targets of the improvement activity.

Continuous improvement involves defining quantitative process improvement objectives with the involvement and sponsorship of management. It is a continuous effort to systematically identify, appraise, implement, and evaluate improvements to the processes.

Management commitment to continuous process improvement is important. Training and incentive programs are established to encourage and enable all personnel to participate in continuous process improvement activities. Improvement opportunities are identified and analyzed in terms of how well they move the organization and its projects toward continuously fulfilling business goals and objectives more efficiently and effectively.

Goals
1. Goals for process improvement are established and progress towards them is evaluated. *(BP 21.01, BP 21.02, BP 21.03, BP 21.06)*
2. Process improvement activities are coordinated across projects and the organization. *(BP 21.02)*
3. Improvements are deployed, monitored, and sustained within the project and organization. *(BP 21.04, BP 21.05, BP 21.07, BP 21.08)*

Notes
A "project" is an organizational element that produces an output or outcome. An "organization" is a unit within which many projects are managed as a whole. An organization shares a common top-level manager and common policies.
A "set of processes" is a group of processes within an organization that share some common characteristics, but that are different enough in their domain of applicability to be considered separate processes.

The following are some basic process improvement concepts:

- Process improvement demands investment, planning, dedicated people, management time, and capital investment.
- Process improvement is a team effort.
- Effective change requires an understanding of the current process and clear goals for improvement.
- Process improvement is continuous – it involves continual learning and evolution.
- Process changes will not be sustained without conscious effort and periodic reinforcement.
- Process improvement is based on process appraisal results and process effectiveness measures that help identify and prioritize improvement actions in relation to needs and business goals.
- Process appraisal produces a current process capability profile that may be compared with a target profile based on needs and business goals.
- Improvement actions identified within a process improvement program are implemented as process improvement projects.

Relationships between this PA and other PAs

This process area covers the continuing activities to improve the performance of processes relating to all process areas. The organization's business goals are determined in Integrated Enterprise Management (PA 00). The initial collection of the organization's process assets and the definition of the organization's set of processes is covered in the Process Definition process area (PA 20). The Process Definition process area (PA 20) provides coordination of the actions for changing the process. Project Management (PA 11) defines the actions for managing the process improvement. Process improvement may result from activities in Quality Assurance and Management (PA 15) or Innovation (PA 23). Innovation (PA 23) defines the actions for adopting and transforming new techniques and technologies into the organization.

Base practices list

BP 21.01 **Identify process improvement goals:** Identify process improvement goals from the organization's business goals.

BP 21.02 **Establish process improvement program:** Plan improvements to the project/organization's processes based on widespread participation and analysis of the impact of potential improvements on achieving the goals of the organization.

BP 21.03 **Appraise processes**: Appraise the processes periodically.

BP 21.04 **Establish an action plan:** Analyze appraisal results and other sources for improvement and establish an action plan for process improvement.

BP 21.05 **Implement improvements:** Implement the process improvement action plan.

BP 21.06 **Confirm improvements:** Confirm that improvement activities meet goals and desired results.

BP 21.07 **Sustain and deploy improvement gains:** Sustain and deploy improvement gains across all applicable parts of the organization/project.

BP 21.08 **Monitor performance:** Continuously monitor and improve process performance.

BP 21.01 Identify process improvement goals

Identify process improvement goals from the organization's business goals.

Description
Identify process improvement goals from the organization's business goals. The process operates in a business context to institutionalize the best practice. Process improvement goals consider the financial, quality, human resource, and marketing issues important to the success of the business. Priorities of process improvement objectives are determined.

Typical Work Products
- goals of the organization's process tied to business needs
- project process improvement goals
- requirements for the organization's process
- requirements for the organization's process asset library
- process asset library
- process improvement plans
- organizational policy

Notes
Establishing goals may include determining the tradeoff criteria for process performance based on time-to-market, quality, and productivity business issues.

The goals are reflected in the organization’s process (see Process Definition (PA 20)). Goals are always measurable, but as the organization/project understands and matures its processes, the goals will be expressed in more quantitative terms.

A process improvement program starts with the recognition of the organization's needs and business goals. This recognition could be derived from any of the following:
- formulation of a mission statement or a long-term vision
- analysis of organization's business goals
- analysis of the organization's current shared values
- the organization's readiness to undertake a process improvement program
- data on quality costs
- other internal or external stimuli

Internal stimuli that may trigger a process improvement program:
- declining or unsatisfactory productivity
- declining staff satisfaction
- senior management change

External stimuli that may trigger a process improvement program:

- feedback from customers
- competitiveness changes in the environment
- requirements to meet specific industry benchmarks
- new requirements from customers and stakeholders

BP 21.02 Establish process improvement program

Establish a process improvement program based on widespread participation and analysis of the impact of potential improvements on achieving the goals of the organization.

Description
The process improvement program is considered a project in its own right, and it is planned, resourced and managed accordingly. A process improvement plan is produced at the beginning of the program and subsequently used to monitor progress. The plan includes the relevant background and history and the current status, if possible expressed in specific, numerical terms. The improvement goals derived from the organization's needs and business goals provide the main requirements for the plan. The plan includes a preliminary identification of the improvement scope in terms of both the organizational boundaries for the improvement program and the processes to be improved.

Projects/organizations may take this opportunity to "mistake-proof" the process and eliminate wasted effort. It is important to make the more effective and efficient processes stable; that is, performed consistently by everyone. Empowering teams to define, design, develop, and deploy improvements subject to process goals related to business goals tends to work well, once measurement has been accepted as a basis to inform decisions. Wide participation on improvement teams is good for morale and deployment buy-in. Piloting the improvements for proof of concept on one project also reduces risk and instability.

Typical Work Products
- process improvement plan
- process improvement program plan
- resources committed to the plan
- process improvement infrastructure
- technical strategy

Notes
The plan should cover all the process improvement steps, although initially the plan may only give outline indications of the later stages. It is important to ensure that key roles are clearly identified, that adequate resources are allocated, that appropriate milestones and review points are established, and that all risks associated with the plan are identified and documented in the plan. The plan should also include activities to keep all those affected by the improvement informed of progress.

Perform tradeoffs on proposed process improvements against estimated returns in areas such as cycle time, productivity, and quality. Use the techniques of the Alternatives Analysis process area (PA 04).

Deployment of process improvements is a challenge. In making improvements, be careful to avoid optimizing locally, and thereby creating problems in other areas.

BP 21.03 Appraise processes

Appraise the processes periodically.

Description
Understanding the strengths and weaknesses of the processes currently being performed is key to establishing a baseline for improvement activities. Processes are identified. Measurements of process performance and lessons learned should be considered in the appraisal. Appraisal can occur in many forms, and appraisal methods should match the culture and needs of the organization. Appraisal results are in a form that may be used to benchmark them against processes used by other organizations.

Typical Work Products
- process capability/maturity profiles
- process performance analyses
- appraisal findings
- as-is process
- gap analyses
- strengths and weaknesses
- measurements of process performance
- process performance baseline

Notes
An example of an appraisal scenario is to appraise current processes using the FAA-iCMM and its associated FAA-iCMM Appraisal Method (FAM). Use the results of the appraisal to establish or update process performance goals.

The appraisal should include both the program-specific processes as well as the organizational process(es).

Additional Practice Guidance
- Determine the degree of program use of the project/organization's process and methods.
- Measure and analyze productivity for each major process activity within the process.

BP 21.04 Establish an action plan

Analyze appraisal results and other sources for improvements and establish an action plan for process improvement.

Description
Information collected during the appraisal, in particular the capability level ratings and strengths/weaknesses, are analyzed and prioritized in light of the organization's need to:

- identify areas for improvement
- set qualitative process goals and quantitative improvement targets
- derive an action plan, and integrate it with the process improvement program plan

Management should approve the areas for improvement, the goals and targets, and the updated process improvement program plan, thereby committing the organization to undertake the planned improvements. The decision should be communicated clearly to all affected staff. The action plan is maintained throughout the process improvement program's lifecycle.

Typical Work Products

- approved process improvement action plan
- revised program plan including action plans
- quantitative targets
- commitment to undertake planned improvements
- implementation plans
- to-be process

Notes
Appraising the process provides momentum for change and the involvement of a spectrum of organizational personnel. This momentum must be harnessed by planning improvements that will provide the most payback for the organization in relation to its business goals. The improvement plans provide a framework for taking advantage of the momentum gained in appraisal. The planning should include targets for improvement that will lead to high-payoff improvements in the process in terms of achieving organizational goals or objectives.

If delays and queues occur in the execution of the current processes, then focus on these areas as starting points for cycle-time reduction. Check process features such as readiness criteria, inputs, and verification mechanisms.

Those implementing the actions and those affected by them should be involved, or be consulted, while developing the plan and in evaluating alternatives, in order to draw on their expertise and to enlist their cooperation.

BP 21.05 Implement improvements

Implement the process improvement action plan.

Description
The process improvement plan is implemented in order to improve the process. The process that is to be implemented is documented and reviewed by appropriate stakeholders and subject matter experts.

Four main tasks are involved in each process improvement project:
- selecting the operational approach to implementation
- preparing and agreeing to the process improvement detailed implementation plan
- implementing the process improvement actions according to the process improvement plan
- monitoring the process improvement project

Typical Work Products
- process implementation plan
- to-be-process description (improved process)
- status reports
- tailoring guidelines
- training material
- sample documents
- checklists
- process definitions

Notes
Implementation may be simple or complex depending on the contents of the action plan included in the updated process improvement program plan and the characteristics of the project/organization. A project/organization may seek out best practices from other organizations similar to their own.

In general, several process improvement projects will be initiated, each concerned with implementing one or more process improvement actions.

A process improvement implementation plan should be developed, including the following:
- objectives of the process improvement project
- approach to implementation
- organization and responsibilities
- time schedule and resources
- risk management, including risk assessment, monitoring and mitigation
- monitoring policy
- specification of success criteria, including process goals and improvement targets
- communication and training in the processes

BP 21.06 Confirm improvements

Confirm that improvement activities meet goals and desired results.

Description
When the process improvement project has been completed, the project/organization:

- confirms that the planned goals and targets have been achieved and that the expected benefits have been delivered
- confirms that the desired organizational culture has been established
- re-evaluates risks associated with the improved process
- re-evaluates costs and benefits

Measurements are used to aid in this confirmation of improvement or appraisal results. Management is involved both to approve the results and to evaluate whether the needs have been met. Corrective actions are taken as needed.

Typical Work Products

- process improvement measurement
- measurement analysis report
- appraisal results
- re-appraisal results
- validated results

Notes
If, after improvement actions have been taken, measurements or appraisal results show that process goals and improvement targets have not been achieved, it may be desirable to redefine the process improvement project or activity by returning to an appropriate earlier practice.

Re-appraisal is one way that improvement can be confirmed (see BP 21.03).

BP 21.07 Sustain and deploy improvement gains

Sustain and deploy improvement gains across all applicable parts of the organization/ project.

Description
After improvement has been confirmed, the process needs to be sustained at the new level of performance. The processes are deployed within the organization so that all those for whom it is applicable use the improved process. This requires management to monitor institutionalization of the improved process, and to give encouragement when necessary.

Responsibilities and processes for monitoring should be documented.

Typical Work Products
- measurements
- measurement analysis report
- quality assurance reports
- deployment plan
- improved process assets entered into process asset library
- training

Notes
If an improved process has been piloted in a restricted area or on a specific project or group of projects, it should be deployed across all areas or projects in the organization where it is applicable. This deployment should be properly planned and the necessary resources assigned to it. The plan should be documented as part of the process improvement plan.

Consideration should be given to:
- who is affected
- how to communicate both the changed process and the benefits expected from it (note: changes should be properly documented and approved)
- what education and training are necessary
- when to introduce changes to the different areas, taking business needs into account
- how to ensure that the changes have been made (for instance by conducting audits)
- how to ensure that the improved process performs as expected

BP 21.08 Monitor performance

Continuously monitor and improve process performance.

Description
The performance of the project/organization's processes and process program should be continuously monitored, and new process improvement projects should be selected and implemented as part of a continuing process improvement program. Additional improvements are always possible. The performance of the organization's process is monitored as it evolves over time. The process improvement program is reviewed regularly by management. The utility of collected process measurements is evaluated.

Typical Work Products
- measurements
- measurement analysis report
- management reviews
- trend analysis
- lessons learned
- further improvement initiatives

Notes
Effectiveness and conformance measures should be chosen to suit the organization's needs and business goals. Management should regularly review their continuing suitability. Joint process reviews may be held with appropriate stakeholders. The risks to the organization and its products from using the process should also be monitored and actions taken as risks materialize or become unacceptable.

Trends in process, service, and product attributes should be analyzed to ensure the desired effects are being sustained.

The regular process improvement program review by management should ensure that:
- both the improvement program and individual improvement projects, including their goals and targets, remain appropriate to the organization's needs
- further improvement projects are initiated when and where appropriate, as earlier improvement projects are completed
- the process improvement process is itself improved in the light of experience
- continuous improvement becomes and remains a feature of the organization's values, attitudes, and behavior

Further process appraisals can be an important component of the continuing improvement program, for instance in the following circumstances:

- where a long-term goal to achieve higher capability levels is to be approached by stages
- when changing organizational needs indicate a requirement to achieve higher capability levels
- when there is a need to give a fresh impetus to improvement

The extent to which improved processes have been institutionalized should be considered before scheduling further process appraisals. It may be more cost-effective to delay appraising a process until improvements have been fully deployed, rather than expend resources appraising a process that is in transition, when the results can be difficult to interpret.

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PA 22: Training

Process Area Summary

Purpose
The purpose of the Training process area is to develop and maintain the skills and knowledge of people so they perform their roles effectively and efficiently.

Major points addressed
Knowledge and skill requirements within the organization, projects, and support groups are identified, as are future knowledge and skill needs (such as those relating to emerging programs or technology, and new products, processes, and policies). Once requirements are identified, individuals that need these skills and knowledge receive appropriate training. Training records are maintained, and the effectiveness of training is assessed to ensure organizational needs are being met.

Successful training programs require an organization's commitment and an environment that encourages learning.

Goals
1. Training needs are solicited and identified from individuals, projects, groups, and the organization. *(BP 22.01, BP 22.02)*
2. Required training is provided in accordance with established plans. *(BP 22.03, BP 22.04, BP 22.05, BP 22.06)*
3. Training effectiveness is assessed. *(BP 22.06, BP 22.07)*

Notes
Successful training programs are administered in a manner that optimizes the learning process and that is repeatable, assessable, and adaptable to meet the changing needs of the organization. Training includes programs for initial knowledge and skill development, as well as refresher programs to ensure currency. Training is not limited to classroom events, but includes other mechanisms to enhance skills and the building of knowledge such as job rotation, on-the-job training, directed self-study courses, seminars, and workshops.

Needed skills and knowledge can be provided both by training within the organization and by timely acquisition of the required capability from sources outside the organization. This process area, however, focuses on ensuring that needed training is received by people within the organization.

Skills and knowledge may be technical, managerial, organizational, or contextual. Technical skills pertain to the ability to use the equipment, tools, materials, data, and processes required by a project or process. Technical knowledge also includes understanding the application domain. Managerial skills include visioning and leadership. 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. For successful training, the organization needs to motivate and encourage learning.

Relationships between this PA and other PAs

The Training process area supports all other process areas ensuring that projects and the organization have the knowledge and skills to perform those processes. Project Management (PA 11) activities determine the needed skills when planning the project, ensure skills are available for the project either through planning for training resident staff, or through obtaining those skills from external sources, using practices of Outsourcing (PA 05). Integrated Enterprise Management (PA 00) establishes expectations regarding individual and organizational learning. Training in new technologies is recommended through practices of the Innovation process area (PA 23). The Information Management process area (PA 17) is used to store and share information that supports learning and knowledge acquisition.

Base practices list

BP 22.01 **Identify training needs:** Identify training needs for the organization, projects, teams, and support groups.

BP 22.02 **Establish training plan:** Establish and maintain a training plan.

BP 22.03 **Establish training mechanism:** Establish and maintain training capability and delivery mechanisms to address identified training needs.

BP 22.04 **Train individuals:** Train individuals to have the skills and knowledge needed to perform their assigned roles.

BP 22.05 **Establish and maintain records:** Establish and maintain records of training and experience.

BP 22.06 **Assess training effectiveness:** Assess the effectiveness of training to meet identified training needs.

BP 22.07 **Establish a learning environment:** Establish and maintain an environment that encourages learning.

BP 22.01 Identify training needs

Identify training needs for the organization, projects, teams, and support groups.

Description
Determine the improvements that are needed in strategic skill and knowledge within the organization and in skill and knowledge within projects, teams, and support groups such as configuration management, measurement, or quality assurance groups. The needs are determined using various inputs from individuals, groups, the organizational strategic plan, and a compilation of existing employee skills. The organizational strategic plan is used to help identify emerging technologies and individual performance requirements. Project inputs help to identify existing deficiencies that may be remedied through training. The existing skill level is used to assess current capability and determine if individuals need training. Mechanisms are established to gather the required information on training needs.

Identification of skill and knowledge needs should also determine those that are common across projects and support groups. Training can then be consolidated to achieve efficiencies of scale and to increase communication via the use of common tools within the organization. Training should be offered in the organization's standard set of processes, if available, and in tailoring the process for specific projects. Some training may be mandated by statutes or organizational policy.

It is essential to ensure that appropriate skill and knowledge are available. Through deliberate assessment and preparation, plans can be developed and executed to make available the range of required knowledge and skills, including technical skills, application problem-domain knowledge, interpersonal skills, multidisciplinary skills, management skills, and process-related skills.

Typical Work Products
- organization’s training needs
- strategic training needs
- project, team, and support group training needs
- common training needs
- project, team, and support group skill or knowledge
- assessment of skill types needed by skill category
- list of identified and available subject matter experts

Notes
Depending on the nature of the organization’s work and on the employees’ responsibilities and stage of organizational and personal development, education and training needs may vary greatly. These needs might include knowledge-sharing skills, communications, teamwork, problem solving, interpreting and using data, meeting customer requirements, process analysis and simplification, waste and cycle time reduction, and priority setting based on strategic alignment or cost/benefit analysis.

Education needs also might include basic skills, such as reading, writing, language, and mathematics.

Project or team training plans are a source for identifying training needs. The organization may identify additional training needs as determined from appraisal findings (see Process Improvement (PA 21)) and as identified by the defect prevention process (see Quality Assurance and Management (PA 15)). Appropriate coverage of the full range of skill and knowledge types can be addressed with a checklist of knowledge types (e.g., functional engineering, problem domain, etc.) against each element of the work breakdown structure.

An example of ensuring the availability of the appropriate application-problem domain knowledge (e.g., satellite weather data processing), would be a plan to interview identified subject matter experts in connection with requirements interpretation or system design. Such an approach would be appropriate when an organization does not have the required expertise available (as with the first program in a new line of business).

Additional Practice Guidance

- Identify needed improvements in skill and knowledge throughout the organization using the programs' needs, organizational strategic plan, and existing employee skills as guidance.
- Base long-term competency development requirements on the organization's strategic plan.
- Establish and maintain the strategic training needs of the organization.
- Balance short- and longer-term organizational and employee needs, including development, learning, and career progression.
- Seek and use input from employees and their supervisors/managers on education and training needs, expectations, and design.
- Address key developmental and training needs, including diversity training, management/leadership development, new employee orientation, and safety, as appropriate.
- Address performance excellence including how employees learn to use performance measurements, performance standards, skill standards, performance improvement, quality control methods, and benchmarking, as appropriate.

BP 22.02 Establish training plan

Establish and maintain a training plan.

Description
A training plan is developed for delivering training and assessing its effectiveness. A training plan might typically include training needs, training topics, training schedules, training methods, requirements, and quality standards for training materials; quality metrics for training; instructor qualifications; training tasks, roles, and responsibilities; and resource requirements including tools, facilities, and staffing. Documented commitments by those responsible for implementing and supporting the plan are essential for the plan to be effective. Revise the plan and commitments as necessary.

Typical Work Products
- organizational training plan
- project knowledge acquisition plan
- training plan
- course announcements
- course catalogues

Notes
The plan pertains to organizational, project, or support group training needs. Each project should develop and maintain a training plan that specifies its training needs. Individual training plans and career progression are discussed in BP 22.07.

Training schedules should consider work schedules and availability of individuals. Determine the scope of the training for which records will be maintained.

BP 22.03 Establish training mechanism

Establish and maintain training capability and delivery mechanisms to address the identified training needs.

Description
Evaluate and select the appropriate method for delivering needed training to individuals in a timely manner. Project and organizational needs are analyzed, and the methods of the Alternatives Analysis process area (PA 04) are employed to choose among alternative delivery mechanisms such as in-house course preparation and delivery, outsourcing to external trainers, or development of structured on-the-job training. Many factors may affect the selection of training approaches, including audience-specific knowledge, costs and schedule, work environment and so on. When selecting an approach consider the means to provide skills and knowledge in the most effective way possible, given the constraints.

Prepare training materials based on the identified training needs for each class that is being developed and facilitated by people within the organization, or obtain the training material for each class that is being procured. Establish and maintain training capability to address training needs.

New courses should be piloted and adjusted as required prior to widespread delivery. Training effectiveness assessment results should be used to adjust training as appropriate.

Typical Work Products
- trade-study results indicating the most effective delivery mechanism
- course descriptions and requirements
- training material
- courses
- pilot course evaluations
- qualified instructors

Notes
Education and training delivery might occur inside or outside the organization and could involve on-the-job, classroom, computer-based, distance learning, or other types of delivery. Training also might occur through developmental assignments within or outside the organization.

Example criteria that may be used to determine the most effective delivery mechanism include:
- time available to prepare training materials
- business objectives
- availability of in-house expertise
- availability of training from external sources
- performance objectives

Examples of training approaches include:

- 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

Examples of external sources of training include:

- customer-provided training
- commercially available training courses
- academic programs
- professional conferences
- seminars

Course descriptions should typically include:

- topics covered in the training
- intended audience
- prerequisites and preparation for participation
- training objectives
- length of training
- cost and location
- lesson plans
- criteria for determining satisfactory completion of the course
- criteria for granting training waivers

Examples of when the training materials and supporting artifacts may need to be revised include:

- 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.)

Prepare:

- procedures for periodically evaluating the effectiveness of the training and special considerations, such as piloting and field testing the training course
- needs for refresher training and opportunities for follow-up training
- materials for training a specific practice to be used as part of the process (e.g., method technique)
- materials for training a process
- materials for training process skills such as statistical techniques, statistical process control, quality tools and techniques, descriptive process modeling, process definition, and process measurement

Review the training material with instructional experts, subject matters experts, and students from the pilot programs.

Additional Practice Guidance

- Assign experienced personnel to perform training.
- Involve management personnel in competency development activities, both as recipients and as participants.
- Seek and use input from employees and their supervisors/managers on education and training needs, expectations, and design.
- Include formal and informal education, training, and learning, as appropriate.

BP 22.04 Train Personnel

Train personnel to have the skills and knowledge needed to perform their assigned roles.

Description
Personnel are trained in accordance with the training plan and developed material. In selecting people to be trained, consider the background of the target population, prerequisites, and the skills and abilities needed by people to perform their roles as managers or practitioners or teams. Training of personnel includes selecting the people who will receive the training, scheduling the training including instructors and facilities, and conducting the training.

Typical Work Products
- trained personnel
- training waiver
- certificates

Notes
Offer the training in a timely manner (just-in-time training) to ensure optimal retention and the highest possible skill level.
- A procedure should exist to determine the skill level of the employee prior to receiving the training.
- A waiver procedure for required training is established and used to determine whether individuals already possess the knowledge and skills required to perform their designated roles.
- Online training/customized instruction modules accommodate different learning styles and cultures, in addition to transferring smaller units of knowledge.

Additional Practice Guidance
- Train personnel to have the skills and knowledge needed to perform their assigned roles.
- Establish a mechanism for granting waivers.
- Involve management personnel in competency development activities, both as recipients and as participants.
- Provide competency development for critical functional areas (e.g., analysis techniques specific to the organization's problem domains).
- Integrate competency development opportunities, such as formal education, in-house training, and on-the-job training.
- Provide cross-discipline technical management training to all disciplines, including program management.
- Train managers of engineering organizations, team leaders, and engineers on the systems engineering process.
- Provide training in the basic principles of systems engineering to quality management, configuration management, and other support personnel.
- Provide training in a variety of forms, including formal training, on-the-job training, and just-in-time training, as required to meet program and individual needs.

- Integrate tools, methods, and procedures for competency development.
- Deliver and evaluate education and training for both the long and the short term.

BP 22.05 Establish and maintain records

Establish and maintain records of training and experience.

Description
Records are maintained to track the training that each employee has received and the employee's skills and capabilities. Track delivery to the training plan and record training statistics.

Course material is maintained in a repository for future access by employees and for maintaining traceability in changes.

Typical Work Products
- training and experience records
- baselined training materials
- revisions to training materials
- training waivers
- training statistics

Notes
Records are kept of all students who successfully complete each training course or other approved training activity, or who have been granted waivers. Also, records of successfully completed training are made available for consideration in the assignment of staff and managers.

Maintain a repository of training materials and make it available to all employees. (For example, the organization's library could make books, notebooks, videotapes, etc., available while soft-copy training materials could be maintained on a public file server.) Incorporate lessons learned into process training materials and the training program. Update process training materials with all process changes and improvements.

Additional Practice Guidance
- Maintain training materials in an accessible repository.

BP 22.06 Assess training effectiveness

Assess the effectiveness of training to meet the identified training needs.

Description
A key aspect of training is determining its effectiveness. Methods of evaluating effectiveness need to be addressed concurrent with the development of the training plan and training material. In some cases, these methods need to be an integral part of the training material. The results of the effectiveness assessment must be reported in a timely manner so that adjustments can be made to the training. Effectiveness includes assessing whether people that need the training actually attend, and if not, determining the causes.

Typical Work Products
- analysis of training effectiveness
- modification to training
- training effectiveness surveys
- training program performance assessments
- instructor and course evaluation forms
- training examinations

Notes
To determine the success of the training, a procedure should exist to determine the skill level of the employee or the organization after receiving the training. This could be accomplished via formal testing, on-the-job skills demonstration, post-training surveys of training participants, surveys of managers' satisfaction with post-training effects, or assessment mechanisms embedded in the courseware. Measures may be taken to assess the effectiveness or added value of the training with respect to organizational, project, or learning or performance objectives. Particular attention should be paid to the need for various training methods, such as training teams as integral work units or assuring that training is offered in a ways that complement work schedules.

When used, performance objectives should be shared with course participants. They should be written unambiguously and stated in a manner that makes them observable and verifiable. The results of the training effectiveness assessment should be used to revise training materials and methods. Assess the effectiveness of training plans in meeting their objectives.

Additional Practice Guidance
- Assess in-progress or completed programs to determine whether staff knowledge was adequate for performing program tasks.
- Provide a mechanism for assessing the effectiveness of each training course with respect to set objectives.
- Require trainers to demonstrate proficiency in the topics for which they intend to train others.

- Provide a mechanism to evaluate students to verify their comprehension of training materials prior to recognition.
- Obtain student evaluations of how well competency development activities meet their needs.
- Establish completion criteria for each training course, documented in standards or course descriptions.
- Provide a mechanism to evaluate alumni capability to perform the style, scope, and intensity of systems engineering that the business needs.
- Deliver and evaluate education and training for both the long and the short term.

BP 22.07 Establish a learning environment

Establish and maintain an environment that encourages learning.

Description
Successful organizations, projects, and training programs require an environment that recognizes and encourages learning. Establish methods for creating and nurturing a learning environment. Carry out and revise these methods as required to assure the organization is receptive to training, and that individuals are motivated to learn. Assure that individuals that need training have the opportunity to receive it.

Typical Work Products
- recognition in staff evaluations of receiving appropriate training
- recognition in staff evaluations of developing and providing training
- awards for competency achievement
- tuition reimbursement programs
- reimbursement for membership in professional societies
- competency certificates
- competency levels
- career plans
- individual training plans
- announcements of training opportunities

Notes
Ensure that a process exists to provide incentives and motivate the students to participate in the training. Methods for establishing a learning environment include providing management attention, training resources, flexibility in work assignments, cost reimbursements, and individual recognition for competency development and training delivery.

Additional Practice Guidance
- Encourage staff to continuously develop skills and knowledge.
- Reward mentoring as a means of increasing staff competency.
- Provide a mechanism to develop individual competency development goals consistent with both the individual's career objectives and the program's needs.
- Provide job opportunity and career advancement based on competency development achievements.
- Clearly state and communicate competency development opportunities and the relationship between competency development and career opportunity to all personnel in the organization.
- Provide a mechanism to formally recognize competency development achievements.
- Provide a mechanism for certification of competency achievement.
- Motivate staff, for example through career development and reward mechanisms.
- Reinforce knowledge and skills on the job.

PA 23: Innovation

Process Area Summary

Purpose
The purpose of the Innovation process area is to identify, select, and introduce selected technology improvements into products, processes, and the work environment to improve the organization's business results.

Major points addressed
In order to improve products, processes, and the work environment, the organization must stay aware of the currunt environment and of technological advances. Technology is inserted when improvements in evolution, cost, schedule, or performance of the organization's products, processes, or process capability can reasonably be expected to result from such improvements. Proper introduction of new technologies requires attention to the needs of users and awareness of potential problems that might occur during implementation; hence, pilot projects are often implemented prior to organization-wide upgrades. In addition, improvements to the work environment are performed in a manner that is minimally disruptive. A technology strategy for innovation is established and used to manage the introduction of new technology.

Goals
1. Agile adaptation to change is driven by the organization's knowledge of its products, processes, technologies, and core competencies. *(BP 23.01, BP 23.02, BP 23.03, BP 23.04, BP 23.05*)
2. The organization's products, services, processes, and work environment are continually evaluated for suitability to use identified improvements and innovations. *(BP 23.03, BP 23.04, BP 23.05)*
3. Selected technologies are deployed to relevant parts of the organization in accordance with the organization's objectives and goals. *(BP 23.02, BP 23.03, BP 23.04)*

Notes
Improvements to the work environment include technologies such as processes, tools, techniques, methodologies, practices, and even management strategies (such as integrated product development, product lines, or performance-based management). The work environment includes facilities and factors such as safety, human, and physical considerations.

Relationships between this PA and other PAs
Results of technology studies are input to the Needs process area (PA 01) to stimulate customer and other stakeholder needs. Improvements in processes are adopted in concert with the practices of Process Definition (PA 20) and Process Improvement (PA 21). Product lines for areas of improvement are defined in Integrated Enterprise Management (PA 00). Insertion of new technology may be accomplished through the applicable life cycle process areas (Needs (PA 01), Requirements (PA 02), Design (PA 03), Design

Implementation (PA 06), Integration (PA 07), Evaluation (PA 08), Deployment, Transition, and Disposal (PA 09), and Operation and Support (PA 10)). Practices of Measurement and Analysis (PA 18) are used to measure the effects of innovation. Risk Management (PA 13) is used to identify and manage risks associated with incorporating, or not incorporating, technology changes. Information on new technology is managed using practices of Information Management (PA 17). The work environment for performing all process areas is considered in the application of Innovation practices. Training for the use of new technologies is provided using practices of Training (PA 22).

Base practices list

BP 23.01 **Maintain new technology awareness:** Maintain awareness of new technologies that support the organization's goals.

BP 23.02 **Select new technologies:** Choose new technologies to adopt based on established criteria.

BP 23.03 **Prepare for infusion:** Perform the necessary preliminary activities to ensure that technology infusion will be successful and will advance the organization's goals.

BP 23.04 **Infuse new technologies:** Insert new technologies into the organization's products, work environment, and processes.

BP 23.05 **Manage innovation:** Manage the innovation of products, processes, and the work environment to support individual projects, improve business results, and ensure easy adoption of further technology improvement initiatives.

BP 23.01 Maintain new technology awareness

Maintain awareness of new technologies that support the organization's goals.

Description
Awareness of the current state of the art or state of the practice is a necessary element for assessing improvement options. Maintain sufficient awareness of new technology applicable to current and projected product lines, and to the work environment. Keep appropriate decision makers informed of new technologies so that they can request insertion when new technologies would be most beneficially adopted. Maintain awareness of projects' and customers' perceived needs for technology changes. Establish and maintain sources and methods for identifying new technology and infrastructure improvements, such as facilities or maintenance services.

Typical Work Products
- reviews of technology applicable to products, services, processes, and the work environment
- lists of perceived technology improvement needs
- technology improvement proposals
- inventory of technology currently in use
- sources for identifying new technology
- methods for identifying new technology

Notes
Examples of activities to maintain awareness of technological advances include:
- reading technical journals
- participating in professional societies
- maintaining a technical library
- soliciting ideas and proposals for technology improvements from projects, process teams, and customers
- systematic searching for technology solutions to project or organizational problems
- capturing and disseminating lessons learned from projects using new technologies

Additional Practice Guidance

- Identify technologies currently in use.
- Identify new product technologies for competitive advantage.
- Encourage innovation within the program.
- Support participation by the organization in technical consortia, societies, and collaborations.
- Establish a mechanism for maintaining awareness and disseminating knowledge of the state-of-the-art technology.
- Regularly review and assess the potential impact of external trends that might affect the work environment.
- Collect and analyze process and technology improvement proposals.
- Identify innovative improvements that would increase the organization's quality and process performance.

BP 23.02 Select new technologies

Choose new technologies to adopt based on established criteria.

Description
Identify needs for technology enhancements and identify new technologies. In accordance with PA 04, Alternatives Analysis, select the best technologies to adopt using appropriate criteria. Choosing new technologies involves determining problems with current technology, what the potential users of the new technology would like to see in the solution, and what the needs of the projects are, including economics and concern for the ease of transition. Assess potential solutions to the technology problems against these criteria, make appropriate modifications to improve the best match, and choose the best solution from the candidate solutions. Prioritize which technology improvements should be implemented first.

Typical Work Products
- technology needs statement
- technology trade study analyses and tradeoffs, including economic analyses
- reviews of technology used or proposed
- user and other requirements for technology changes
- selected technologies for insertion, with justification
- implementation priorities

Notes
Appropriate technologies could include newly developed technologies, but could also include applying mature technologies in different applications, or maintaining current methods. Factors to consider in choosing new technologies may include worth to the organization and risk.

Consider technologies to improve the quality of product lines and the productivity of engineering and operating activities. Consider facility upgrades.

Examples of activities to develop a detailed technology needs statement include:
- determine the organization's needs for computer network performance, improved analysis methods, business and technical software, or process restructuring
- determine how to obtain required process measurements in a background automated manner so that metric gathering is not intrusive
- provide ways to collect feedback from users on the benefits and drawbacks of the current work environment and on suggested improvements

The work environment may also include any of the following: safety, human, and physical factors, software productivity tools, systems engineering tools, systems analysis and simulation tools, proprietary tools, customized versions of commercially available tools, special test equipment, and facilities.

Additional Practice Guidance

- Establish a mechanism for monitoring the life cycle of currently used technologies and use this knowledge to plan for replacement of technologies approaching obsolescence.
- Perform cost/benefit analyses prior to the adoption of new technologies.
- Identify, discriminate, and insert product and process technology improvements.
- Determine requirements for the work environment based on program-specific needs.
- Include the needs of each program as part of a documented set of requirements for the work environment.
- Include the business goals of the organization in determining the documented requirements for the work environment.
- Pilot process and technology improvements to select which ones to implement.
- Select process and technology improvement proposals for deployment across the organization.

BP 23.03 Prepare for infusion

Perform the necessary preliminary activities to ensure that technology infusion will be successful and will advance the organization's goals.

Description
Once the appropriate technology to be inserted has been selected, take steps to ensure the insertion will be successful. Establish a strategy for technology deployment, and plan and execute pilot efforts to determine the feasibility or economics of untried or advanced technologies, and to measure results. Plans for insertion should be reviewed with affected personnel and consideration should be given to transition time and costs, including training. Prepare to provide consultation and assistance to pilot projects and to projects involved in broader insertion. Ensure critical components are available to support planned product evolution, as applicable.

Typical Work Products
- technology deployment strategy
- pilot project plans and documented results, including the decision whether to proceed to broader insertion of the technology
- statement of transition risks and workarounds
- critical components for product evolution
- revised strategy based on pilots

Notes
Affected groups might include planners, software engineering, systems engineering, test, quality assurance, configuration management, contract management, and documentation support in addition to the projects directly involved in the pilot or broader infusion of the technology.

Use pilot efforts to assess new and unproven technologies before they are incorporated into the product line or across the organization. Revise the deployment strategy as required based on pilot results.

The availability of critical components can be ensured by incorporating their use in product line requirements.

Additional Practice Guidance
- Require appropriate analysis within the organization before new product or process technology insertion is allowed.
- Pilot new tools prior to including them in the systems engineering work environment.
- Establish and maintain the plans for deploying the selected process and technology improvements.

BP 23.04 Infuse new technologies

Infuse new technologies into the organization's products, work environment, and processes.

Description
Following the deployment strategy, the organization's products, processes, and work environment are updated with new technologies found to support the organization's business goals and the projects' needs. Training in the use of the new technology is provided. In addition, the organization's and projects' processes are modified as required to conform to use of the new technologies.

Typical Work Products
- new work environment
- process changes
- improved products
- training in new technology

Notes
Incorporation of process changes is discussed in PA 21, Process Improvement. Technology infusion may necessitate process improvements.

To minimize insertion difficulties, consider the following steps:
- test the new technology prior to insertion
- decide where in the organization to insert the improvements
- notify those affected by the impending change as early as possible
- provide necessary training in use of the new technology
- monitor the acceptance of the new technology and take additional steps where needed

Additional Practice Guidance
- Establish a mechanism for managing and supporting the introduction of new product or process technologies.
- Identify, discriminate, and insert product and process technology improvements.
- Upgrade or add support tools or facilities that enhance the ability to meet the organization’s requirements.

BP 23.05 Manage innovation

Manage the innovation of products, processes, and the work environment to support individual projects, improve business results, and ensure easy adoption of further technology improvement initiatives.

Description
Create a technology strategy for innovation. Manage the introduction of new technologies to increase value to customers and to improve the competitive position of the organization. The effects of innovation are measured and used to monitor innovation.

The technology strategy improves the total work environment and responds to the needs of the organization as a whole. An individual project, however, may have unique needs for selected elements of this environment. In this case, tailoring the elements of the environment can allow the project to operate more efficiently. In addition, maintenance of the work environment must be conducted to ensure satisfaction of the users with the technology improvements.

User satisfaction will not only improve business results, but will also foster acceptance of future initiatives to insert technology.

Typical Work Products
- technical strategy for innovation
- tailored work environment
- work environment performance reporting
- work environment user satisfaction ratings

Notes
Examples of tailoring include:
- removing signal processing automation tools from the work environments of projects that do not involve signal processing
- adding specific tools to the work environment of a project that needs more extensive tools than are needed organization-wide (for example, when particular tools are called out by a customer).

Examples of work environment maintenance include:
- hiring or training computer system administrators
- development of expert users in selected automation tools
- development of methodology or process experts, who can be used on a variety of projects

Additional Practice Guidance
- Establish a mechanism for managing and supporting the introduction of new product or process technologies.
- Review the effectiveness of newly introduced technologies (product or process) to verify analysis used to justify its introduction.

- Demonstrate that the achievement of specific business goals (e.g., increased profitability, increased market share, reduced time to market) can be directly attributable to the insertion of new product or process technology.
- Deploy a work environment that supports program needs.
- Tailor the work environment to individual program needs.
- Maximize integration of tools within the environment.
- Maintain the work environment to continuously support the programs.
- Retire support tools or facilities that no longer support the organization's requirements.
- Collect and analyze process and technology improvement proposals.
- Collect data on the systems engineering work environment usage and performance.
- Measure the effects of the deployed process and technology improvements.

Part 3: Appendices

Appendix A: Change Request Form and Change History

Appendix B: Glossary

Appendix C: References

Appendix D: Mapping Tables

Appendix A: Change Request Form and Change History

Change Request Form

We welcome suggestions for improvement. Please include the following information with your change requests:

Name/Organization:	Phone:	Email:
Title of change:	Section/Paragraph number	Page number
Detailed description of change:		
Impact if change is not addressed/incorporated:		
Suggested solution		

Submit to: linda.ibrahim@faa.gov **with a cc: to**: nancy.ctr.depoy@faa.gov.

Change History

Version 1.0	November 1997
Version 2.0	September 2001

Appendix B: Glossary

This glossary defines many of the terms or phrases used in the model. In general, the terminology in the model is intended in its everyday sense, or as would be understood by a practitioner in the area where the term is introduced. Some definitions, however, are provided here in cases where additional clarity might be required.

The iCMM draws on several standards or models, each having glossaries or definitions. When developing the iCMM version 1.0, the glossaries of all three source models were included. Based on experience using iCMM version 1.0, this approach was not found to be particularly helpful.

iCMM version 2.0 integrates eight standards/models and we are not including all of those glossaries here. Furthermore, some of the source standards are specific to software, some to systems, some to quality management, and some to organizational performance management. Since the iCMM integrates these topics, terms introduced in this glossary have typically been generalized, as appropriate, to reflect the multidisciplinary nature of the iCMM process areas and practices, as well as general applicability to products and services. However, since [PQA] and [MBNQA] bring some new concepts not included in the iCMM before, selected definitions from these sources are provided in full.

A reference to the part(s) of the model that use the term is included, when appropriate, to enhance glossary usefulness and to indicate where more information about the topic may be found.

Material in this glossary is selected/adapted from the following sources. When more than one source is listed, the definition combines or integrates the information provided in the listed sources.

Source Abbreviation	Reference (see Appendix C) or Explanation
iCMM	The definition was developed for iCMM version 2.0, or is adapted from definitions provided in [FAA-iCMM 97]
CMMI	[CMMI-SE/SW/IPPD]
15504	[ISO/IEC TR 15504]
12207	[IEEE/EIA 12207]
731	[EIA/IS 731]
15288	[ISO/IEC CD 15288]
ISO 9000	[ISO 9000]
PQA/MBNQA	[PQA] and [MBNQA]

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
acquirer (general, PA 12)	An organization, stakeholder or individual that acquires, procures or obtains a system, product or service from a supplier. An acquirer could be called a buyer, customer, owner, user or purchaser.	iCMM, 12207, 15288, 731
action plans (PA 00)	Action plans refer to principal organization-level drivers, derived from short- and long-term strategic planning. In simplest terms, action plans are set to accomplish those things the organization must do well for its strategy to succeed. Action plan development represents the critical stage in planning when general strategies and goals are made specific so that effective organization-wide understanding and deployment are possible. Deployment of action plans requires analysis of overall resource needs and creation of aligned measures for all work units. Deployment might also require specialized training for some employees or recruitment of personnel. An example of an action plan element for a government organization supplying goods and services in competition with private-sector suppliers might be to develop and maintain a price leadership position. Deployment should entail the design of efficient processes, analysis of resource and asset use, and creation of related measures of resource and asset productivity, aligned for the organization as a whole. It might also involve the use of a cost-accounting system that provides activity-level cost information to support day-to-day work. Unit and/or team training should include priority setting based upon costs and benefits. Organization-level analysis and review should emphasize overall productivity growth. Ongoing competitive analysis and planning should remain sensitive to technological and other changes that might greatly reduce operating costs for the organization or its competitors. (Note there are action plans at lower levels than those described above. See, for example, "process improvement action plan.")	PQA/ MBNQA
alignment (PA 00)	Alignment refers to unification of goals throughout the organization and consistency of processes, information, resource decisions, actions, results, analysis, and learning to support key organization-wide goals. Effective alignment requires common understanding of purposes and goals and use of complementary measures and information to enable planning, tracking, analysis, and improvement at three levels: the organization level, the key process level, and the work unit level.	PQA/ MBNQA
appraisal	(See "process appraisal")	
architecture (PA 03)	A high-level design that provides decisions made about: the problems that the product will solve, component or element descriptions, relationships between elements, and dynamic operation description; a structure that identifies components or elements, specifies interfaces and relationships among them, and services provided by them to accomplish required functionality. Architectural elements may be personnel, hardware, software, facilities, data, information, materials, services or techniques. Architectural elements of systems may themselves be subsystems.	731, iCMM

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
audit (PA 15, PA 16)	An independent examination of products, services and processes to determine the extent to which audit criteria (e.g. policies, procedures, requirements, specifications, standards, contractual agreements, or other criteria) are fulfilled.	iCMM, ISO 9000, 12207, 731, CMMI
base practice (Chapter 2, Chapter 5)	A practice that summarizes a fundamental essential characteristic of performing a process that meets the purpose of the process area to which this base practice is related.	iCMM
baseline (PA 16)	A reviewed, approved and agreed upon product, regardless of media, formally designated and fixed at a specific time, which serves thereafter as the basis for defining and managing change.	iCMM, 12207, 731, 15288, CMMI
benchmarking (PA 21)	The process of systematically comparing and measuring products, services, and processes against "best practices," "best-in-class" achievements, and performance of similar activities, inside or outside government. At its essence, benchmarking involves systematically looking at proven ways to provide better customer service and adapting these ways to an organization's operations. It turns the "not-invented-here" philosophy on its head, by focusing on the best practices of other organizations. The continuous process of measuring products, services and practices against the toughest competitors or those companies recognized as industry leaders.	PQA/ MBNQA, 731
capability dimension (Chapter 4)	The part of a reference model that comprises capability levels and their component goals and generic practices.	iCMM, 15504
capability level (Chapter 2, Chapter 4)	Degree of process improvement for individual process areas in which all goals up to that level are attained. Capability levels are described by generic practices and summarized by capability level goals.	iCMM, CMMI
common cause of variation (Chapter 4)	The variation of process performance results that exists because of random, normal, and expected interactions among the components of a process and the environment. Causes of natural variation inherent in a process or system. Removing common causes of variation involves making changes to the process itself. These causes are usually minor and do not cause a process to go out of control. An example is wear and tear on equipment causing greater tolerance variation in an output, such as a drink filler at a fast-food restaurant.	iCMM, CMMI, 731
concept of operations	(See "operational concept.")	
configuration control board (PA 16)	A group of people responsible for evaluating and approving or disapproving proposed changes to configuration items, and for ensuring implementation of approved changes. Configuration control boards are also known as change control boards.	CMMI

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
configuration item (PA 16)	An entity or aggregation of work products that is designated for configuration management, treated as a single entity in the configuration management process, and that can be uniquely identified at a given reference point.	iCMM, CMMI, 731, 12207
continuous architecture (Chapter 2, general)	A capability model in which each process area can be rated at a capability level and in which the using organization determines the priority for improving individual process areas. Identical generic practices apply to all process areas and are used to demonstrate increasing capability. This model contrasts with the staged model that establishes sets of process areas that must be performed before other sets in a priority order of increasing maturity. A continuous architecture is also called a continuous representation.	731, iCMM
continuous with staging representation (Chapter 2, general)	The description of a reference model that is structured into a process dimension and a capability dimension (according to the continuous architecture) and that also provides staging or groupings of process areas into maturity levels. The continuous with staging representation explicitly enables organizations to improve any process areas, in any order, to any capability level desired based on business objectives. It also captures staging guidance reflected in models with a staged architecture so that organizations can follow those priorities, if desired. As in the continuous representation, generic practices are staged into capability levels.	iCMM
corrective action (Chapter 4, PA 00, PA 11, PA 15, PA 10)	An action taken to bring expected future performance into compliance with the plan, eliminate the cause and prevent recurrence of a detected nonconformity or other undesirable situation, remove an error, adjust a condition, or remedy a situation.	iCMM, ISO 9000, 731, CMMI
cost effectiveness generic attribute (Chapter 2)	The cost effectiveness generic attribute indicates the extent to which the value received is worth the resources invested in producing the products or results.	iCMM
customer satisfaction (PA 01)	Customer's perception of the degree to which the customer's requirements, needs and expectations have been fulfilled.	iCMM, ISO 9000
customers (Chapter 2, general)	External customers are those who use or are directly affected by the organization's products or services—those for whom the organization is in business. They can be grouped into classifications according to their relationship to the government as a supplier: voluntary, entitled, and compelled users of the organization's products or services. Voluntary users choose to use the product/service, such as visitors to national parks and users of government statistics. Entitled users have an automatic legal right to benefit from the program, such as recipients of social security benefits and users of veterans hospitals. Compelled users fall under the jurisdiction of government programs that are prescriptive in nature, where punitive action can be taken if users do not comply (e.g., prison inmates). Internal customers are employees within the organization who receive goods and services produced elsewhere in the organization and act upon them in the production chain, ultimately leading to the organization's final output of goods and services	PQA/ MBNQA

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
cycle time (Chapter 4, PA 18)	Cycle time refers to responsiveness and completion-time measures—the time required to fulfill commitments or to complete tasks. Cycle time improvement could include time to market, order fulfillment time, delivery time, changeover time, and other key process times.	PQA/ MBNQA
deactivation (PA 09)	Deactivation involves notification of users that the product or service is being replaced or withdrawn from operation.	iCMM
defect (PA 08, PA 15)	Non-fulfillment of a requirement related to an intended or specified use.	ISO 9000
defect density (PA 15, PA 18)	Number of defects per unit of product size (e.g., problem reports per 1000 lines of code).	CMMI
defined process (Chapter 4)	A capability level 3 process is called a defined process. A defined process is a managed, planned and tracked (capability level 2) 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.	iCMM, CMMI
deployment (PA 09)	Deployment of a product or service involves planning and preparation activities associated with the placement of a product or service into an operation and support environment.	iCMM
deployment (PA 00)	Deployment refers to the extent to which an organization's approach is applied. Deployment is evaluated on the basis of the breadth and depth of the application of the approach throughout the organization.	PQA/ MBNQA
derived measure (PA 18)	A function of two or more base measures.	iCMM
disposition (PA 09)	Disposition involves disassembly of the replaced item including the satisfaction of relevant health, safety and security regulations. If appropriate, it includes breaking down the replaced item into manageable elements to facilitate removal for reuse, recycling, reconditioning, overhaul or destruction.	iCMM
empowerment (PA 00, PA 14)	Empowerment refers to giving employees the authority and responsibility to make decisions and take actions. Empowerment results in decisions being made closest to the "front line," where work-related knowledge and understanding reside. Empowerment is aimed at enabling employees to satisfy customers on first contact, to improve processes and increase productivity, and to better the organization's business results. Empowered employees require information to make appropriate decisions; thus, an organizational requirement is to provide that information in a timely and useful way.	PQA/ MBNQA
evaluation (PA 08)	A systematic determination of the extent to which an entity meets its specified criteria.	12207

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
generic attribute (Chapter 2)	A generic attribute is a way of measuring process performance results, independently of capability and maturity level. Generic attributes encompass two characteristics of the performance of a process area: usefulness and cost effectiveness.	iCMM
generic practice (Chapter 4)	A practice that enhances the capability to perform any process. Generic practices are added to the base practices of a process area to create a higher capability process. They are applicable to any process area.	iCMM, 731, CMMI
goal - performance goal (PA 00)	Performance goal refers to a target level of performance expressed as a tangible, measurable objective against which actual achievement can be compared, including a goal expressed as a quantitative standard, value, or rate.	PQA/ MBNQA
goal - quality objective, quality goal (PA 15, PA 00)	Something sought, or aimed for, related to quality; for a product, specific objectives, which if met, provide a level of confidence that the quality of a product is satisfactory.	ISO 9000, 731, CMMI
goal - (in a model) (Chapter 4, Chapter 5)	In a reference model, a goal summarizes an observable, expected state to be achieved if practices mapped to that goal are performed. Each process area has goals and the base practices of a process area map to its goals. Each capability level has a goal and all generic practices at that level map to that goal. Process goals may also be called process outcomes, which are observable results of the successful implementation of a process. Process goals or outcomes form part of the description of each process area in the reference model.	iCMM, 15504
goals - process improvement goals (PA 00, PA 21, Chapter 4)	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.).	CMMI
high-performance work (PA 00)	High performance work refers to work approaches used to systematically pursue ever higher levels of overall organizational and human performance, including quality, productivity, innovation rate, and time performance. Approaches to high-performance work vary in form, function, and incentive systems. Effective approaches generally include: cooperation between management and the workforce, including work force bargaining units; cooperation among work units, often involving teams; self-managed/self-directed responsibility (sometimes called empowerment); individual and organizational skill building and learning; flexibility in job design and work assignments; an organizational structure with minimum layering ("flattened") where decision making is decentralized and decisions are made closest to the "front-line;" and regular use of performance measures, including comparisons. Some high-performance work systems use monetary and non-monetary incentives based upon factors such as organizational performance, team and/or individual contributions, and skill building. Also, some high-performance work approaches attempt to align the design of organizations, work, jobs, and incentives.	PQA/ MBNQA

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
incomplete process (Chapter 4)	A capability level 0 process is called an incomplete process. An incomplete process is either not performed or partially performed. One or more of the goals of the process area are not achieved. The process is not implemented.	iCMM, CMMI
infrastructure (PA 11, Chapter 4, PA 23, general)	All the systematic elements needed to operate an entity or to sustain an initiative or effort. These include: people's skills and knowledge or the training to transition them into use, methods or techniques, materials, services, facilities, and tools which may or may not be automated.	iCMM, ISO 9000, 731
institutionalization (Chapter 4)	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.	731, CMMI
leadership system (PA 00)	Leadership system refers to how leadership is exercised throughout the organization—the basis for the way that key decisions are made, communicated, and carried out. It includes structures and mechanisms for making decisions and reinforcing values, expectations, and behaviors. It also includes the formal and informal bases and mechanisms for leadership development used to select leaders and managers, to develop their leadership skills, and to provide guidance and examples regarding behaviors and practices. An effective leadership system creates clear values respecting the capabilities and requirements of employees and organization stakeholders, and sets high expectations for performance and performance improvement. It builds loyalty and teamwork based upon the values and the pursuit of shared purposes. It encourages and supports initiative and risk taking, subordinates organization to purpose and function, and minimizes reliance on chains of command that require long decision paths. An effective leadership system includes mechanisms for the leaders' self-examination, receipt of feedback, and improvement.	PQA/ MBNQA
life cycle (general, PA 11)	A general term covering all phases of the evolution of a product or service beginning with concept definition and continuing through the disposal of the product or service. Also known as product, service, or system life cycle. A project life cycle spans the life of a project from inception to completion; a development life cycle covers inception to completion of development.	iCMM
life cycle model (PA 11)	A partitioning of the life of a product or service into phases that guide the project from identifying customer needs through product or service retirement. A framework containing the processes, activities, and tasks involved in the development, operation, and maintenance of a product or service, It spans the life of the system from the definition of its requirements to the termination of its use. This framework also acts as a common reference for communication and understanding.	CMMI, 12207, 15288, iCMM
maintenance (general, PA 10)	The process of modifying a product or component after delivery to correct faults, adapt to a changed environment, improve performance or other attributes, or perform line and depot maintenance of hardware components. That is, it includes maintenance that may be corrective, adaptive, or perfective.	731

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	*Definition*	*Source*
managed process (Chapter 4)	A capability level 2 process is called a managed (planned and tracked) process. A managed process is a performed (capability level 1) process that is also planned and tracked. The process is managed to ensure its institutionalization, and to ensure the achievement of specific objectives for the process, such as customer satisfaction, cost, schedule, and quality objectives.	iCMM, CMMI
maturity level (Chapter 2)	Degree of process improvement across a predefined set of process areas and capability levels in which all goals within the set are attained.	iCMM, CMMI
measure (PA 18)	Property, attribute, scale or unit which is used for quantification	iCMM
Measurement (PA 18)	The process of assigning quantitative values to measures or properties according to some defined criteria. This process can be based on estimation or direct measurement. Also, a value resulting from performing the measurement process.	iCMM
measures and indicators (PA 18)	Measures and indicators refer to numerical information that quantifies (measures) input, output, and performance dimensions of processes, products, services, and the overall organization (outcomes). Measures and indicators might be simple (derived from one measurement) or composite. However, some users of these terms use the term indicator: (1) when the measurement relates to performance rather than to inputs; (2) when the measurement relates to performance but is not a direct or exclusive measure of such performance (e.g., the number of complaints is an indicator of dissatisfaction, but not a direct or exclusive measure of it); and (3) when a performance or measure is a predictor ("leading indicator") of some more significant performance (e.g., gain in customer satisfaction might be a leading indicator of increased demand).	PQA/ MBNQA
natural bounds (PA 18, Chapter 4)	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.	CMMI
need (PA 01, PA 23)	A stakeholder-related capability shortfall (such as those documented in a need statement, field deficiency report, or engineering change order), or an opportunity to satisfy a new market or capability because of a new technology application or breakthrough, or to reduce costs. Needs may also relate to providing a desired service (e.g., testing, contracting, or system disposal), to providing an opportunity (e.g., learning opportunity), or to providing a work product such as a document or report.	iCMM, 731
objective review (PA 15)	An evaluation of activities and work products against criteria that minimize subjectivity and bias by the reviewer. An example of an objective review is an audit against requirements, standards, or procedures by an independent quality assurance function.	CMMI
objectively verify (PA 15, Chapter 4)	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.	CMMI

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
operational concept (PA 01)	A general description of the way in which an entity is used or operates from the user's point of view. A user-oriented document that describes a system's operational characteristics from the end user's viewpoint (IEEE Std 1362-1998). (Also known as a concept of operations or operational concept description.)	iCMM, CMMI
operational scenario (PA 01, PA 03)	A sequence of events expected during operation of products and services. Includes the environmental conditions and usage rates as well as expected stimuli (inputs) and responses (outputs). A description of an imagined sequence of events that includes the interaction of the product or service with its environment and users, as well as interaction among its components.	731, CMMI, iCMM
optimizing process (Chapter 4)	A capability level 5 process is called an optimizing process. An optimizing process is a quantitatively managed (capability level 4) process that is changed and adapted to meet relevant current and projected business objectives.	iCMM, CMMI
organizational process maturity (Chapter 2, general)	The extent to which an organization has explicitly and consistently deployed processes that are documented, managed, measured, controlled, and continually improved. Organization process maturity may be measured via a process appraisal.	731, CMMI
organizational unit (appraised) (Chapter 3)	That part of an organization that is the subject of an appraisal. NOTE 1 An organizational unit deploys one or more processes that have a coherent process context and operates within a coherent set of business goals. NOTE 2 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.	15504, CMMI

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
performance (PA 00, Chapter 4, general)	Performance refers to outcome results obtained from processes, products, and services that permit evaluation and comparison relative to goals, standards, past results, and other organizations. Most commonly, the results address quality, efficiency and time, and might be expressed in non-financial and financial terms. Some types of organization performance are: operational, including product and service quality; customer-related; financial; mission/program; supplier. Operational performance refers to performance relative to effectiveness and efficiency measures and indicators. Examples include cycle time, productivity, waste reduction, and regulatory compliance. Operational performance might be measured at the work unit level, the key process level, and the organization level. Product and service quality performance refers to performance relative to measures and indicators of product and service requirements derived from customer preference information. Examples include reliability, on-time delivery, defect levels, and service response time. Product and service quality performance generally relates to the organization as a whole. Customer-related performance refers to performance relative to measures and indicators of customers' perceptions, reactions, and behaviors. Examples include customer retention, complaints, customer survey results, and changes in demand for products and services. Customer-related performance generally relates to the organization as a whole. Financial performance refers to performance using measures of cost and revenue, including asset utilization, asset growth, value added per employee, cost savings and cost avoidances. Financial measures are generally tracked throughout the organization and are also aggregated to give organization-level, composite measures of performance. Examples are return on investment and return on assets. Mission/program performance refers to non-financial measures used to assess the organization's success in achieving its intended purposes, goals and objectives. As with financial performance measures, they generally are tracked throughout the organization and are also aggregated to give organization-level, composite measures of performance. Supplier performance refers to measures of: (1) supplier and partner-provided goods and services used by the organization in developing its final goods and services, and (2) services provided by contractor employees working within the organization, but supervised by the contractor.	PQA/ MBNQA
performed process (Chapter 4)	A capability level 1 process is called a performed process. A performed process is a process that achieves the goals of the process area.	iCMM
policy (PA 00, Chapter 4)	Guiding principles designed to influence and determine decisions, actions, or other matters. Senior management typically establishes organizational policy.	731, CMMI, iCMM
policy - quality policy (PA 00, Chapter 4, PA 15)	Overall intentions and direction of an organization related to quality as formally expressed by top management; provides a framework for setting quality objectives, which are something sought, or aimed for, related to quality	ISO 9000
practice (general)	An activity that contributes to the creation of the output (work products) of a process or enhances the capability of a process.	15504

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
preventive action (PA 15, PA 10)	An action to eliminate the cause of a potential nonconformity or other undesirable potential situation.	ISO 9000
procedure (general)	A specified way to carry out an activity or a process. A description of a course of action to perform a given task.	ISO 9000, 731
process (general)	Process refers to linked activities with the purpose of producing a product or service for a customer (user) within or outside the organization. Generally, processes involve combinations of people, machines, tools, techniques, and materials in a systematic series of steps or actions. In some situations, process performance might require adherence to a specific sequence of steps, with documentation (sometimes formal) of procedures and requirements, including well-defined measurement and control steps. In many service situations, particularly when customers are directly involved in one or more steps of the service, process is used in a more general way to spell out what must be done, possibly including a preferred or expected sequence. If a sequence is critical, the service needs to include information for customers to help them understand and adhere to the sequence. Service processes involving customers require guidance to the servers on handling contingencies related to differing circumstances and to customers' actions or behaviors. In some cases, such as strategic planning, research, development, and analysis, process does not necessarily imply formal sequences of steps. Rather, process implies general understanding regarding competent performance, such as timing, options to be included, evaluation, and reporting. Sequences might arise as part of these understandings.	PQA/ MBNQA
	A set of activities performed to achieve a purpose. An organized set of interrelated or interacting activities that, together, use resources to transform inputs into outputs.	iCMM, 12207, 15504, ISO 9000, 731, 15288
process action team (general)	A team that has the responsibility to develop and implement process improvement activities for an organization as documented in the process improvement action plan.	CMMI
process appraisal (Chapter 2, Chapter 3, PA 21)	Comparison of processes being practiced to a reference model or standard; a disciplined evaluation of an organization's processes against a reference model	iCMM, 15504
process area (Chapter 2, Chapter 5)	A group of related base practices that are essential for achieving the purpose of the process area.	iCMM
process area category (Chapter 2, Chapter 5)	A set of process areas addressing the same general type or area of activity	iCMM, 15504

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
process asset (PA 20)	Anything that the organization considers useful in attaining the goals of a process area.	CMMI
process asset library (PA 20)	A collection of process asset holdings that can be used by an organization or project. (May also be called a "process asset repository" or a "process database.")	CMMI, iCMM
process capability (Chapter 4)	The range of expected results that can be achieved by following a process. The ability of a process to achieve a required goal.	731, 15504,
process database (PA 18, PA 20, Chapter 4)	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. (May also be called a "process asset library" or "repository.")	CMMI, 731
process description (Chapter 4, PA 20)	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.	CMMI
process dimension (Chapter 2, Chapter 5)	The part of a reference model that comprises process areas and their component goals and base practices. The set of process areas comprise the functional aspects of the reference model. The process areas are grouped into categories of related activities.	iCMM, 15504
process group (general)	A group or collection of specialists that facilitate the definition, maintenance, and improvement of the processes used by the organization. It defines and documents the process, establishes and defines process metrics, supports program data gathering, assists programs in analyzing data, and advises management of areas requiring further attention.	731, CMMI
process improvement (general, Chapter 3, PA 21)	Actions taken to change processes so that they meet business needs and achieve business goals more effectively. Process improvement includes both the actions designed to improve the performance and maturity of processes, and the results of such actions.	iCMM, 15504, CMMI
process improvement action plan (PA 21, Chapter 3, general)	A plan to improve all or part of the process. NOTE A process improvement action can contribute to the achievement of more than one process goal.	iCMM, 15504
process improvement program (PA 21, Chapter 3)	All the strategies, policies, goals, responsibilities and activities concerned with the achievement of specified improvement goals. NOTE A process improvement program can span more than one complete cycle of process improvement.	15504

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
process improvement project (PA 21, Chapter 3)	Any subset of the process improvement program that forms a coherent set of actions to achieve a specific improvement.	15504
process management (Chapter 4, PA 21)	The set of activities, methods, tools, and infrastructure used to define, implement, monitor, predict, evaluate, control, and improve the performance of a process. The focus on process management implies that a project or organization accounts for both product and process-related factors in business planning, performance, evaluation, monitoring, and corrective action.	iCMM, 731
process maturity (general)	The extent to which a process is explicitly documented, managed, measured, controlled, and continually improved.	731
process measurements (PA 18, PA 11, PA 15)	Quantitative data used for assessing a process and its resulting work products for the purpose of characterizing and understanding the process, and identifying corrective actions to be taken.	iCMM, 731, CMMI
process owner (PA 20)	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 or the managed process. A process may therefore have multiple owners at different levels of responsibility.	iCMM, CMMI
process performance (Chapter 4)	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).	CMMI
	The extent to which the execution of a process achieves its purpose.	15504
process performance baseline (Chapter 3, PA 21)	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.	CMMI, 731
product (general)	A product is a work product that is delivered to the customer. It is any output or observable outcome of an activity or process, including those from services, intended for delivery to a customer or end user. This includes: (1) An item that is the goal of the engineering of a system. (2) A constituent part of the system. (3) Goods and services A product is sometimes referred to as an “end-product.”	CMMI, 731, iCMM
	Result of a process. Note: There are 4 generic product categories: services, software, hardware, processed material.	ISO 9000
product line (PA 00)	A group of products sharing a common, managed set of features that satisfy specific needs of a selected market or mission.	CMMI

Term or Phrase *(iCMM reference)*	*Definition*	*Source*
productivity (PA 00, PA 18)	Productivity refers to measures of efficiency of the use of resources. Although the term is often applied to single factors, such as manpower (labor productivity), machines, materials, energy, and capital, the productivity concept applies as well to the total resources consumed in producing outputs. Overall productivity, usually called total factor productivity, is determined by combining the productivity of the different resources used for an output. The combination usually requires taking a weighted average of the different single factor productivity measures, where the weights typically reflect costs of the resources. The use of an aggregate measure such as total factor productivity allows a determination of whether or not the net effect of overall changes in a process, possibly involving resource tradeoffs, is beneficial. Effective approaches to performance management require understanding and measuring single-factor and total-factor productivity, particularly in complex cases when there are a variety of costs and potential benefits.	PQA/ MBNQA
project (Chapter 2, PA 11, general)	An undertaking that develops and/or maintains one or more products or provides a service. A project typically has its own funding, cost accounting, and schedule. It may be structured as a team, task force, or other entity used by the organization to produce products or provide services to a customer. Projects may be called by various names in different organizational contexts, such as product teams, service teams, business units, management units, or programs.	iCMM
quality (general, PA 15)	The degree to which a set of inherent characteristics of a product, service, or process fulfills requirements; the attribute of a product, by which satisfaction of requirements is measured; the ability of a set of inherent characteristics of a product, product component, or process to fulfill requirements of customers.	iCMM, ISO 9000, 731, CMMI
quality assurance (PA 15)	A part of quality management focused on providing confidence that quality requirements will be fulfilled; a planned and systematic means for assuring management that defined standards, practices, procedures, and methods of the process are applied; all the planned and systematic activities implemented, and demonstrated as needed, to provide adequate confidence that an entity will fulfill requirements for quality.	ISO 9000, CMMI, 12207
quality improvement (PA 15)	Part of quality management focused on increasing the ability to fulfill quality requirements (requirements can be related to any aspect such as effectiveness, efficiency, or traceability).	ISO 9000
quality management system (PA 15)	A management system (a system to establish policy and objectives and to achieve those objectives) to direct and control an organization with regard to quality	ISO 9000
quality manual (PA 15)	Document specifying the quality management system of an organization.	ISO 9000
quantitatively managed process (Chapter 4)	A capability level 4 process is called a quantitatively managed process. A quantitatively managed process is a defined (capability level 3) process that is controlled using statistical and other quantitative techniques.	iCMM, CMMI

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
reference model (general)	A model that is used as a benchmark for measuring some attribute.	CMMI, 731
requirement (PA 02)	A condition or capability that must be met.	iCMM
results (PA 00, PA 11, PA 18)	Results refer to outcomes achieved. Results are evaluated on the basis of current performance; performance relative to appropriate comparisons; rate, breadth, and importance of performance improvements; and relationship of results measures to key organizational performance requirements.	PQA/ MBNQA
rework (general)	action on a nonconforming product to make it conform to the requirements	ISO 9000
service (general)	A product category, service is the result of at least one activity necessarily performed at the interface between the supplier and customer and is generally intangible. Provision of a service can involve, for example, the following: - an activity performed on a customer-supplied tangible product (e.g. automobile to be repaired) - an activity performed on a customer-supplied intangible product (e.g. income statement needed to prepare tax return) - delivery of an intangible product (e.g. delivery of information in context of knowledge transmission) - creation of ambience for the customer (e.g. in hotels and restaurants)	ISO 9000
special cause of process variation (PA 18, Chapter 4)	A cause of a defect that is specific to some transient circumstance and not an inherent part of a process. Special causes of variation are assignable to people, places, materials, events, and so forth.	CMMI, 731
stable process (Chapter 4, PA 15, PA 18)	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.	CMMI
staged architecture (general, Chapter 2)	A capability model in which sets of process areas are defined as maturity levels that must be completed before other sets are attempted. This explicit prioritization of process areas establishes an infrastructure or other dependencies perceived to exist by the model developers or community. Contrast with the continuous architecture in which all process areas have explicit equal priority, and increasing process capability is within those process areas chosen by the organization to improve. A staged architecture is also called a staged representation.	731, iCMM
stakeholder (Chapter 2, general, PA 01)	A group or individual that is affected by or is in some way accountable for the outcome of an undertaking; an interested party having a right, share or claim in a product or service, or in its success in possessing qualities that meet that party's needs and/or expectations. Examples of stakeholders include customers, developers, engineering, management, manufacturing, users, etc.	iCMM, CMMI, 15288, 731

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
standard process (PA 20, Chapter 4)	The operational definition of the basic process that guides the establishment of a common process in an organization NOTE A standard process describes the fundamental process elements that are expected to be incorporated into any defined process. It also describes the relationships (e.g., ordering and interfaces) between these process elements. (See defined process.)	15504
standard processes-organization's set of (PA 20, Chapter 4)	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.	CMMI
statistical process control (Chapter 4, PA 18)	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. Establishment and use of statistical process control chart(s) (any or all of several types) to measure and identify out-of-control conditions in a process and take action to return the process to an in-control state.	CMMI, 731
statistical technique (PA 18)	An analytic technique that employs statistical methods (e.g., statistical process control, confidence intervals, prediction intervals).	CMMI
strategic planning (PA 00)	Strategic planning is the process of setting strategic directions and determining key action plans, and for translating plans into an effective performance management system. The process leads to establishment of general goals and objectives, including outcome-related goals and objectives, for the major functions and operations of the organization, and for establishment of annual performance goals linked to the general goals and objectives. It addresses: (1) how the goals and objectives are to be achieved, including operational processes, skills and technology, and human capital; (2) information and other resources required to meet those goals and objectives; (3) key factors external to the organization and beyond its control that could significantly affect the achievement of the general goals and objectives; and (4) how evaluations are used in establishing or revising goals and objectives. The term “Strategic Planning,” is consistent with the requirements established by the Government Performance and Results Act.	PQA/ MBNQA
supplier (general, PA 12)	An organization or an individual that enters into an agreement with the acquirer or customer for providing a product or service under the terms of the agreement. The supplier may be called, for example, the producer, developer, contractor, seller, vendor, distributor, importer, assembler or service organization. The supplier can be either external or internal to the organization.	iCMM, 12207 15288, 731, ISO 9000, 15504, CMMI
system (general)	A set or combination or integrated composite of interacting or interrelated elements or components (e.g., people, products, services, processes, hardware, software, facilities) organized to achieve one or more stated purposes, or to provide a capability to satisfy a stated need or objective. A system may be considered as a product and/or as the services it provides.	iCMM, 15288, ISO 9000, 731, 12207

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
systematic – (approaches) (general)	Systematic refers to approaches that are repeatable and use data and information so that improvement and learning are possible. In other words, approaches are systematic if they build the opportunity for evaluation and learning, and thereby permit a gain in maturity. As organizational approaches mature, they become more systematic and reflect cycles of evaluation and learning.	PQA/ MBNQA
test (PA 08)	An activity in which a system, product, or a component is used under specified conditions, the results are observed or recorded, and an evaluation is made as to whether it adequately meets some or all of its requirements. Determination of one or more characteristics according to a procedure.	731, ISO 9000
transition (PA 09)	Transition involves transfer of the product or service from the supplier to the customer/stakeholder operation and support organizations.	iCMM
usefulness generic attribute (Chapter 2)	The usefulness generic attribute indicates the extent to which work products or services provide the needed benefits in actual use.	iCMM
validation (PA 08)	Confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use or application are fulfilled. An activity that ensures that an end product stakeholder's true needs and expectations are met. Confirmation that the product, as provided, will fulfill its intended use. It asks "Did I build the right product or service?" NOTES - In design and development, validation concerns the process of examining a product to determine conformity with user needs. -Validation is normally performed on the final product under defined operating conditions. It may be useful or necessary in earlier stages and on incremental work products. - Multiple validations may be carried out if there are different intended uses. - Validation for a system is the set of activities ensuring and gaining confidence that the system is able to accomplish its intended use, goals and objectives.	12207, ISO 9000, 15288, 731, CMMI, iCMM
value (GAs, PA 04, PA 00)	Value refers to the degree of worth relative to cost and relative to possible alternatives of a product, service, process, asset, or function. Organizations frequently use value considerations to determine the benefits of various options relative to their costs, such as the value of various product and service combinations to customers. Organizations seek to deliver value to all their stakeholders. This frequently requires balancing value for customers and other stakeholders, such as employees and the community.	PQA/ MBNQA

Appendix B: Glossary

Term or Phrase *(iCMM reference)*	***Definition***	***Source***
verification (PA 08)	Confirmation by examination and provision of objective evidence that specified requirements have been fulfilled. Confirmation that work products properly reflect the requirements specified for them. It asks "Did I build the product or service right?" NOTES - In design and development, verification concerns the process of examining the result of a given activity to determine conformity with the stated requirement for that activity. - Verification in a system life cycle context is a set of activities that compares a system life cycle product against the required characteristics for that product. The system life cycle products may include, but are not limited to, specified requirements, design description and the system itself. - An activity that ensures that the selected design solution satisfies the detailed technical requirements.	12207, ISO 9000, CMMI, 15288, 731, iCMM
version control (PA 16)	A less formal level of control used to manage work products, as determined by the configuration management strategy.	iCMM
work environment (PA 23)	Set of conditions under which work is performed. It includes the facilities, support environment and infrastructure that people need to perform their jobs effectively.	iCMM, ISO 9000
work product (general)	Any artifact or anything produced by a process. This may include files, documents, parts of a product, services, processes, specifications, and invoices. Examples of processes as work products include a manufacturing process, a training process, and a disposal process. A work product might be used, produced or changed by a process. A work product may be called an "end-product" (to be delivered to a customer) or an "incremental work product" (a early version or representation of an end-product).	CMMI, 731, 15504, iCMM

Appendix C: References

This appendix lists sources that were used in developing this document plus other references.

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Appendix D: Mapping Tables

High-Level Mapping Tables of FAA-iCMM Process Areas to Related Standards and References

The two tables in this appendix provide high-level mappings of the FAA-iCMM v2.0 and v1.0 process areas to their major sources at the process level. In some cases, some practices within these processes are mapped to practices in other process areas, but only the *major* sources are identified in this table.

Detailed practice-level mappings to sources for FAA-iCMM v2.0 and v1.0 practices are included in the supplement to this appendix, available separately. Also, for FAA-iCMM v2.0, that supplement provides practice-level mappings by source model, indicating how the FAA-iCMM v2.0 covers each of its major sources. Note that in several cases, generic practices of the FAA-iCMM v2.0 cover source model elements, and mappings to generic practices are included in the supplement.

Table 1 provides high-level mappings of FAA-iCMM v2.0 process areas to their major sources. This table is in two parts.

Part 1 of this table maps the **FAA-iCMM v2.0** process areas to:

- **FAA-iCMM v1.0** [FAA-iCMM 97] and [HFE],
- **ISO 9001:2000** [ISO 9001] clauses and/or subclauses
- **EIA/IS 731** [EIA/IS 731] focus areas
- **CMMI-SE/SW/IPPD/A** [CMMI-SE/SW/IPPD] and [CMMI-SE/SW/A] process areas
- **Malcolm Baldrige National Quality Award** [MBNQA]/**President's Quality Award** [PQA] categories and/or items

Part 2 of this table maps the **FAA-iCMM v2.0** process areas to:

- **ISO/IEC TR 15504** [ISO/IEC TR 15504] processes
- **IEEE/EIA (ISO/IEC) 12207** [IEEE/EIA 12207] processes
- **ISO/IEC CD 15288** [ISO/IEC CD 15288] processes
- Other Sources, if applicable, including [IPD-CMM], [EIA-632], [SA-CMM 99], [PSM], [P-CMM], others listed

Table 2 provides high-level mappings of **FAA-iCMM v1.0** [FAA-iCMM 97] process areas to their major sources. These sources are:

- **Systems Engineering CMM** [SE CMM]
- **Software Acquisition CMM** [SA-CMM 97]
- **CMM for Software** [SW-CMM 93]

Table 1: FAA-iCMM v2.0 Process Areas and their Major Sources - Part 1

FAA-iCMM v2.0 Process Area	***FAA-iCMM v1.0 Process Area***	***ISO 9001:2000 Subclause***	***EIA/IS 731 Focus Area***	***CMMI-SE/SW/IPPD*/A*** Process Area***	***MBNQA/PQA Category/item***
PA 00 Integrated Enterprise Management	PA 10 Product Evolution	5.1 Management commitment 5.3 Quality policy 5.4.1 Quality objectives 5.5.3 Internal communication 5.6 Management review 6.1 Provision of resources	-	*Organizational Environment for Integration Organizational Process Performance	1.1 Organizational Leadership 1.2 Public/Organization Responsibility and Citizenship 2.1 Strategy Development 2.2 Strategy Deployment 7. Business Results
PA 01 Needs	PA 01 Needs PA 24 Human Factors Engineering	5.2 Customer Focus 7.2.1 Determination of requirements related to the product 7.2.3 Customer communication 8.2.1 Customer satisfaction	1.1 Define Stakeholder and System Level Requirements	Requirements Development	3.1 Customer and Market Knowledge 3.2 Customer Satisfaction and Relationships 6.1 Product and Service Processes
PA 02 Requirements	PA 02 Requirements PA 24 Human Factors Engineering	7.2.1 Determination of requirements related to the product 7.2.2 Review of requirements related to the product 7.3.2 Design and development inputs 5.2 Customer Focus	1.1 Define Stakeholder and System Level Requirements 1.2 Define Technical Problem	Requirements Development Requirements Management	3.1 Customer and Market Knowledge 6.1 Product and Service Processes
PA 03 Design	PA 03 Architecture	7.3.3 Design and development outputs	1.3 Define Solution	Technical Solution	6.1 Product and Service Processes
PA 04 Alternatives Analysis	PA 04 Alternatives	-	1.4 Assess and Select	Decision Analysis and Resolution	6.2 Support Processes 2. Strategic Planning

Table 1: FAA-iCMM v2.0 Process Areas and their Major Sources - Part 1

FAA-iCMM v2.0 Process Area	***FAA-iCMM v1.0 Process Area***	***ISO 9001:2000 Subclause***	***EIA/IS 731 Focus Area***	***CMMI-SE/SW/IPPD*/A** Process Area***	***MBNQA/PQA Category/item***
PA 05 Outsourcing	PA 05 Outsourcing	7.4.1 Purchasing process	2.4 Coordinate with Suppliers	Supplier Agreement Management ****Supplier Selection and Monitoring** **Integrated Supplier Management	6.3 Supplier and Partnering Processes
PA 06 Design Implementation	PA 06 Software Development and Maintenance	7.3.3 Design and development outputs	-	Technical Solution	6.1 Product and Service Processes
PA 07 Integration	PA 07 Integration	-	1.5 Integrate System	Product Integration	6.1 Product and Service Processes
PA 08 Evaluation	PA 08 System Test and Evaluation PA 17 Peer Review	7.3.4 Design and development review 7.3.5 Design and development verification 7.3.6 Design and development validation 7.4.3 Verification of purchased product 8.2.4 Monitoring and measurement of product 8.3 Control of nonconforming product	1.6 Verify System 1.7 Validate System	Verification Validation	6.1 Product and Service Processes
PA 09 Deployment, Transition, and Disposal	PA 09 Transition	7.5 Production and service provision 7.5.1 Control of product and service provision 7.5.5 Preservation of product	-	Supplier Agreement Management Product Integration ** Supplier Selection and Monitoring	6.1 Product and Service Processes

Table 1: FAA-iCMM v2.0 Process Areas and their Major Sources - Part 1

FAA-iCMM v2.0 Process Area	***FAA-iCMM v1.0 Process Area***	***ISO 9001:2000 Subclause***	***EIA/IS 731 Focus Area***	***CMMI-SE/SW/IPPD*/A** Process Area***	***MBNQA/PQA Category/item***
PA 10 Operation and Support	-	7.5.1 Control of production and service provision 8.5.2 Corrective action 8.5.3 Preventive action	-	-	3.2 Customer Satisfaction and Relationships 6.1 Product and Service Processes
PA 11 Project Management	PA 11 Project Management	7.1 Planning of product realization 7.3.1 Design and development planning 8.5.2 Corrective action	2.1 Plan and Organize 2.2 Monitor and Control	Project Planning Project Monitoring and Control *Integrated Project Management Quantitative Project Management	6.1 Product and Service Processes
PA 12 Supplier Agreement Management	PA 12 Contract Management	7.4.1 Purchasing process 7.4.3 Verification of purchased product	2.4 Coordinate with Suppliers	Supplier Agreement Management **Supplier Selection and Monitoring **Integrated Supplier Management **Quantitative Supplier Management	6.3 Supplier and Partnering Processes 7. Business Results
PA 13 Risk Management	PA 13 Risk Management	8.5.3 Preventive action	2.5 Manage Risk	Risk Management	6.2 Support processes 1.2 Organization Responsibility and Citizenship
PA 14 Integrated Teaming	PA 14 Coordination	-	2.3 Integrate Disciplines	*Integrated Teaming *Organizational Environment for Integration * Integrated Project Management	5.1a Work Systems and Job Design

Table 1: FAA-iCMM v2.0 Process Areas and their Major Sources - Part 1

FAA-iCMM v2.0 Process Area	***FAA-iCMM v1.0 Process Area***	***ISO 9001:2000 Subclause***	***EIA/IS 731 Focus Area***	***CMMI-SE/SW/IPPD*/A** Process Area***	***MBNQA/PQA Category/item***
PA 15 Quality Assurance & Management	PA 15 Quality Assurance & Management PA 19 Prevention	4.1 General requirements 7.5.4 Customer property 7.5.2 Validation of processes for production and service provision 8.2.2 Internal audit 8.2.3 Monitoring and measurement of processes 8.2.4 Monitoring and measurement of product 8.4 Analysis of Data 8.5.2 Corrective Action 8.5.3 Preventive action	2.8 Ensure Quality	Process and Product Quality Assurance Causal Analysis and Resolution ** Quantitative Supplier Management	6.2 Support Processes
PA 16 Configuration Management	PA 16 Configuration Management	4.2.3 Control of documents 4.2.4 Control of records 7.5.3 Identification and traceability 7.5.4 Customer property	2.7 Manage Configurations	Configuration Management	6.2 Support Processes
PA 17 Information Management	-	4.2.3 Control of documents 4.2.4 Control of records 7.5.4 Customer property	2.6 Manage Data	-	6.2 Support Processes
PA 18 Measurement and Analysis	PA 18 Measurement	7.6 Control of monitoring and measuring devices 8.2.3 Monitoring and measurement of processes 8.2.4 Monitoring and measurement of product 8.4 Analysis of data	2.2 Monitor and Control	Measurement and Analysis Organizational Process Performance Quantitative Project Management Causal Analysis and Resolution	4.1 Measurement of Organizational Performance 4.2 Analysis of Organizational Performance 6.2 Support Processes 7. Business Results (all items)
PA 19 (reserved)					

Table 1: FAA-iCMM v2.0 Process Areas and their Major Sources - Part 1

FAA-iCMM v2.0 Process Area	***FAA-iCMM v1.0 Process Area***	***ISO 9001:2000 Subclause***	***EIA/IS 731 Focus Area***	***CMMI-SE/SW/IPPD*/A** Process Area***	***MBNQA/PQA Category/item***
PA 20 Process Definition	PA 20 Organization Process Definition	4.1 General requirements 4.2.1 General 4.2.2 Quality Manual 8.5.1 Continual improvement	3.1 Define and Improve the Systems Engineering Process	Organizational Process Focus Organizational Process Definition	6.Process Management (all items)
PA 21 Process Improvement	PA 21 Organization Process Improvement	4.1 General requirements 4.2.1 General 8.5.1 Continual improvement	3.1 Define and Improve the Systems Engineering Process	Organizational Process Focus	6. Process Management (all items)
PA 22 Training	PA 22 Training	6.2.2 Competence, awareness, and training	3.2 Manage Competency	Organizational Training	5.2 Employee Education, Training, and Development 6.2 Support Processes
PA 23 Innovation	PA 23 Innovation PA 10 Product Evolution	6.3 Infrastructure 6.4 Work Environment	3.3 Manage Technology 3.4 Manage Systems Engineering Support Environment	Organizational Innovation and Deployment *Organizational Environment for Integration	6.1 Product and Service Processes 6.2 Support Processes 5.3a Work Environment
Areas* not *covered in FAA-iCMM v2.0	None	None	None	None	5.1a Work systems and Job Design – those aspects pertaining to organizational recruitment and employee performance management

* For CMMI, these process areas are specific to the Integrated Product and Process Development (IPPD) extensions to the CMMI-SE/SW model. Note that the IPPD version of Integrated Project Management was used in this mapping.
** For CMMI, these process areas are specific to the draft Acquisition (A) extensions to the CMMI-SE/SW model.

Table 1: FAA-iCMM v2.0 Process Areas and their Major Sources - Part 2

FAA-iCMM v2.0 Process Area	***ISO/IEC TR 15504 Processes (with process type*)***	***IEEE/EIA (ISO/IEC) 12207 Software life cycle processes***	***ISO/IEC CD 15288 System Life Cycle Processes***	***Other Sources***
PA 00 Integrated Enterprise Management	ORG.1 Organizational alignment (new) CUS.2 Supply	5.2 Supply	5.1.2 Supply 5.2.1 Enterprise Environment Management 5.2.2 Investment Management	IPD-CMM (v0.98) PA 18 Shared Vision PA 19 Organizational Leadership
PA 01 Needs	ENG.1 Development (basic) ENG.2 System and software maintenance (basic) CUS.3 Requirements elicitation (new) CUS.4.2 Customer support (ext component) ENG1.1 System requirements analysis and design (component)	5.1 Acquisition	5.4.1 Stakeholder Requirements Definition	
PA 02 Requirements	ENG.1 Development (basic) ENG.2 System and software maintenance (basic) CUS.3 Requirements elicitation (new) ENG1.1 System requirements analysis and design (component) ENG.1.2 Software requiremts analysis (com	5.1 Acquisition 5.2 Supply 5.3 Development 5.5 Maintenance	5.4.2 Requirements Analysis 5.4.10 Maintenance	
PA 03 Design	ENG.1 Development (basic) ENG.2 System and software maintenance (basic) ENG1.1 System requirements analysis and design (component) ENG.1.3 Software design (component)	5.3 Development 5.5 Maintenance	5.4.3 Architectural Design	ANSI/EIA-632-1999 4.3.2 Solution Definition IEEE Std 1220-1998 6.5 Synthesis
PA 04 Alternatives Analysis	-	-	5.3.4 Decision Making	ANSI/EIA-632-1999 4.5.1 Systems Analysis Process

Table 1: FAA-iCMM v2.0 Process Areas and their Major Sources - Part 2

FAA-iCMM v2.0 Process Area	*ISO/IEC TR 15504 Processes (with process type*)*	*IEEE/EIA (ISO/IEC) 12207 Software life cycle processes*	*ISO/IEC CD 15288 System Life Cycle Processes*	*Other Sources*
PA 05 Outsourcing	CUS.1 Acquisition (basic) CUS.1.1 Acquisition preparation (component) CUS.1.2 Supplier selection (component)	5.1 Acquisition	5.1.1 Acquisition	
PA 06 Design Implementation	ENG.1 Development (basic) ENG.2 System and software maintenance (basic) ENG.1.4 Software construction (component)	5.3 Development 5.5 Maintenance	5.4.4 Implementation	ANS/EIA-632-1999: Product Realization
PA 07 Integration	ENG.1 Development (basic) ENG.2 System and software maintenance (basic) ENG.1.7 System integration & testing (comp) ENG.1.5 Software integration (component)	5.3 Development	5.4.5 Integration	EIA-632 System Design, Product Realization, Application Key Concepts
PA 08 Evaluation	ENG.1 Development (basic) ENG.2 System and software maintenance (basic) CUS.1.4 Customer acceptance (component) ENG.1.6 Software testing (component) ENG.1.7 System integration and testing (component) SUP.4 Verification (basic) SUP.5 Validation (basic) SUP.6 Joint review (basic)	5.1 Acquisition 5.2 Supply 5.3 Development 5.4 Operation 5.5 Maintenance 6.4 Verification 6.5 Validation 6.6 Joint review	5.4.6 Verification 5.4.8 Validation	
PA 09 Deployment, Transition, and Disposal	ENG.1 Development (basic) ENG.2 System and software maintenance (basic) CUS.2 Supply (basic) ENG.1 Development (basic)	5.2 Supply 5.3 Development 5.5 Maintenance	5.4.4 Implementation 5.4.7 Transition 5.4.11 Disposal	EIA/IS-632 Implementation; Transition to Use

Table 1: FAA-iCMM v2.0 Process Areas and their Major Sources - Part 2

FAA-iCMM v2.0 Process Area	***ISO/IEC TR 15504 Processes (with process type*)***	***IEEE/EIA (ISO/IEC) 12207 Software life cycle processes***	***ISO/IEC CD 15288 System Life Cycle Processes***	***Other Sources***
PA 10 Operation and Support	CUS.4 Operation (extended) CUS.4.1 Operational use (ext. component) CUS.4.2 Customer support (ext. component) SUP.8 Problem resolution (basic)	5.4 Operation	5.4.9 Operation 5.4.10 Maintenance	
PA 11 Project Management	CUS.2 Supply (basic) (+ all relevant PAs) MAN.1 Management (basic) MAN.2 Project management (new) SUP.6 Joint Review	5.2 Supply (+ all relevant PAs) 6.6 Joint review 7.1 Management	5.1.2 Supply 5.3.1 Project Planning 5.3.2 Project Assessment 5.3.3 Project Control	
PA 12 Supplier Agreement Management	CUS.1 Acquisition (basic) CUS.1.3 Supplier monitoring (component) CUS.1.4 Customer acceptance process	5.1 Acquisition 5.2 Supply 6.3 Quality Assurance	5.1.1 Acquisition Supply (to negotiate agreement)	SA-CMM v1.02 Contract Tracking and Oversight Contract Performance
PA 13 Risk Management	MAN.4 Risk management (new)	-	5.3.5 Risk Management	
PA 14 Integrated Teaming	ORG.1 Organizational Alignment (new) ORG.3 Human resource management (ext)	-	5.2.4 Resource Management	
PA 15 Quality Assurance & Management	SUP.3 Quality assurance (basic) MAN.3 Quality management (new) SUP.7 Audit (basic) SUP.8 Problem resolution (basic)	6.3 Quality Assurance 6.7 Audit 6. 8 Problem resolution	-	
PA 16Configuration Management	SUP.2 Configuration management (basic)	6.2 Configuration Management	5.3.6 Configuration Management	
PA 17 Information Management	SUP.1 Documentation (extended) (documentation developed in relevant PA) ORG.6 Reuse (new)	5.5 Maintenance 6.1 Documentation (documentation produced in relevant PA)	5.3.7 Information Management 5.2.4 Resource Management	

Table 1: FAA-iCMM v2.0 Process Areas and their Major Sources - Part 2

FAA-iCMM v2.0 Process Area	***ISO/IEC TR 15504 Processes (with process type*)***	***IEEE/EIA (ISO/IEC) 12207 Software life cycle processes***	***ISO/IEC CD 15288 System Life Cycle Processes***	***Other Sources***
PA 18 Measurement and Analysis	ORG.5 Measurement (new)	7.3 Improvement	5.2.3 System Life Cycle Processes Management	[PSM] ISO/TR10017:1999(E) – Guidance on Statistical Techniques for ISO9001: 1994
PA 19 (reserved)				
PA 20 Process Definition	ORG.2 Improvement process (basic) ORG.2.1 Process establishment (component) ORG.6 Reuse (new)	7.3 Improvement	5.2.3 System Life Cycle Processes Management	
PA 21 Process Improvement	ORG.2 Improvement process (basic) ORG.2.1 Process establishment (component) ORG2.2 Process assessment (component) ORG2.3 Process improvement (component) 15504 Part 7: Guidelines for Process Improvement	7.3 Improvement	5.2.1 Enterprise Environment Management 5.2.3 System Life Cycle Processes Management	
PA 22 Training	ORG.3 Human resource management (extended)	7.4 Training	5.2.4 Resource Management	People CMM: Training Knowledge and Skills Analysis
PA 23 Innovation	ORG.4 Infrastructure (basic)	7.2 Infrastructure	-	
Areas not covered in FAA-iCMM v2.0	ORG.3 Human Resource management (extended) – practices regarding recruitment, staff evaluation, and staff records	None	Resource Management – activities regarding recruitment, retention, personnel pool, and staff review	N/a

*ISO/IEC 15504 process types are:
Basic – processes identical in intent to processes in ISO/IEC 12207
Extended – processes that are expansions of ISO/IEC 12207 processes
New – processes that are outside the scope of ISO/IEC 12207
Component – processes (group of one or more ISO/IEC 12207's activities from same process)
Extended Component – processes that are one or more of ISO/IEC 12207's activities from same process, with additional material.

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Table 2: FAA-iCMM v1.0 Process Areas and their Major Sources

FAA-iCMM v1.0 Process Area	***Systems Engineering [SE-CMM] Process Area***	***Software Acquisition [SA-CMM 96] Key Process Area***	***Software Engineering [SW-CMM 93] Key Process Area***
PA 01 Needs	Understand Customer Needs & Expectations	-	-
PA 02 Requirements	Derive & Allocate Requirements	Requirements Development & Management	Requirements Management SW Product Engineering
PA 03 Architecture	Evolve System Architecture	-	SW Product Engineering
PA 04 Alternatives	Analyze Candidate Solutions	-	-
PA 05 Outsourcing	Coordinate with Suppliers	Solicitation	SW Subcontract Management
PA 06 Software Development and Maintenance	-	-	SW Product Engineering
PA 07 Integration	Integrate System	-	SW Product Engineering
PA 08 System Test and Evaluation	Verify &Validate System	Evaluation	SW Product Engineering
PA 09 Transition	-	Transition to Support	-
PA 10 Product Evolution	Manage Product Line Evolution	-	-
PA 11 Project Management	Plan Technical Effort Monitor & Control Technical Effort	SW Acquisition Planning Project Management Project Performance Management	SW Project Planning SW Project Tracking and Oversight Integrated SW Management
PA 12 Contract Management	*(* Coordinate with Suppliers)*	Contract Tracking and Oversight Contract Performance Management	SW Subcontract Management
PA 13 Risk Management	Manage Risk	Acquisition Risk Management	Integrated SW Management
PA 14 Coordination	Integrate Disciplines		Intergroup Coordination
PA 15 Quality Assurance & Management	Ensure Quality		SW Quality Assurance

Appendix D: Mapping Tables

Table 2: FAA-iCMM v1.0 Process Areas and their Major Sources

FAA-iCMM v1.0 Process Area	***Systems Engineering [SE-CMM] Process Area***	***Software Acquisition [SA-CMM 96] Key Process Area***	***Software Engineering [SW-CMM 93] Key Process Area***
PA 16 Configuration Management	Manage Configurations		SW Configuration Management
PA 17 Peer Review	Level 3 Common Features		Peer Reviews
PA 18 Measurement	Level 4 Common Features	Quantitative Process Management Quantitative Acquisition Management	Quantitative Process Management SW Quality Management
PA 19 Prevention	Level 5 Common Features	-	Defect Prevention
PA 20 Organization Process Definition	Define Organization's Systems Engineering Process	Process Definition and Maintenance	Organization Process Focus Organization Process Definition
PA 21 Organization Process Improvement	Improve Organization's Systems Engineering Process	Continuous Process Improvement	Process Change Management
PA 22 Training	Provide Ongoing Skills & Knowledge	Training Program	Training Program
PA 23 Innovation	Manage Systems Engineering Support Environment	Acquisition Innovation Management	Technology Change Management
Areas not covered in FAA-iCMM v1.0	None	None	None