Software Acquisition Improvement Framework (SAIF) Definition

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Abstract

The Software Acquisition Improvement Framework (SAIF) is a computer-aided system that supports the improvement of an organization's software acquisition process capability and performance. The framework integrates an acquisition-process reference model, such as the Software Acquisition Capability Maturity Model[SM] (SA-CMM[®]); a process that defines the improvement approach, such as the SEI's IDEAL[SM] method; plus guidance and other artifacts, which support the use of the model and improvement process. The guidance and artifacts are stored in a repository that automatically links them to the rest of the framework. This linking is structured to ensure that the reference model, the improvement process, and the supporting artifacts are available to the organization at the right time in the improvement process phases and to focus on the areas for which the organization seeks improvement. This document discusses rationale behind the need for the SAIF, the elements constituting the SAIF, and the intended operational usage of the SAIF.

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[SM] Capability Maturity Model and IDEAL are service marks of Carnegie Mellon University.

1. Introduction

This section presents an overview of the current software practice in the Department of Defense (DoD) software acquisition environment, a framework to improve system and software acquisition processes, and an overview of the Software Acquisition Improvement Framework (SAIF) architecture.

1.1 Current Software Acquisition Practice

In the Department of Defense (DOD) acquisition environment, most software is acquired and developed as one of many components of a larger system. Typically, the software acquisition follows the guidelines and framework of the system acquisition. In this context, the software acquisition process, and any improvement to this process, may be suppressed by the requirement to address the system-related issues. This suppression, in turn, can lead to poor management of that portion of the acquisition related to software.

No two acquisition programs are identical. Each program has unique aspects relating to technology, cost, schedule, priority, and funding. However, there is usually a common life cycle and acquisition pattern underlying all major DOD and industry programs.

Reform of the federal acquisition process is now a reality. Public Law 103-355, commonly referred to as the Federal Acquisition Streamlining Act of 1994, was established to facilitate a more equitable balance between government-unique requirements and the need to lower the government's cost of doing business. While the Act was being formulated, the Office of the Secretary of Defense (OSD) charted the Defense Science Board (DSB) Task Force on Acquiring Defense Software Commercially. The objectives of the DSB were to do the following:

- Determine conditions under which procurement of defense software could include commercial practices and determine the changes to the Federal Acquisition Regulations (FARs) that would be required to permit such inclusion.
- Develop an acquisition strategy that incorporates commercial practices.
- Compare the proposed strategy with the current DOD strategy.
- Define institutional mechanisms to assure that the recommendations are implemented.

So many far-reaching recommendations emerged from the study that the Office of the Secretary of Defense Acquisition and Technology/C31 (OSDA&T/C3I) chartered a Software Management Review Council (SMRC) to assure that these recommendations were successfully implemented. The SMRC had the support of the OSD-chartered Software Best

Practices initiative. This initiative focused on improving and restructuring the way DOD manages the acquisition of software.

Despite the subsequent implementation of some of these recommendations, many defense programs still do not meet their objectives because of the software inherent to their systems. A high percentage of the time, software is delivered late and fails to meet the user's needs. Extensive cost overruns and schedule slips are commonplace due, in large part, to software's lack of visibility in the larger system acquisition process. The software acquisition process typically cannot accommodate changes in requirements, or inadequate estimates of the task size and the time required to develop the product. Even if changing requirements and inadequate estimates were not an issue, the program manager (PM) typically lacks institutionalized and measurable processes, practices, methods, and techniques that support successful management of software acquisition.

Acquisition organizations, in general, must improve their software-engineering and acquisition processes and the practices that implement these processes. Project managers and other acquisition managers need ways to improve their software acquisition processes that take advantage of Acquisition Reform policies and find effective practices to implement these processes. The federal government and industry agree that the acquisition community would benefit from improved software acquisition processes. A framework would provide a vehicle to effect these improvements.

1.2 Approach for Acquisition Process Improvement

Process improvement for developers of software-intensive systems has taken on multiple dimensions as the technologies for altering the software-development process evolve and multiply. In addition to a *reference model*, such as the Software Capability Maturity Model (SW-CMM) or ISO 9000, the developer must choose or create a process for the improvement effort itself [Paulk 93a, Paulk 93b, ISO 9000]. Popular *process-improvement* models, such as Shewart's Plan Do Check Act (PDCA) model or the Software Engineering Institute's IDEAL model, may be used or adapted to form the basis for improvement effort activities [Deming 86, McFeeley 96]. The reference model and process improvement model must be brought together and then integrated with *artifacts* such as guidance documents and how-to practices that support implementing the improvement approach.

This approach of combining the three dimensions of process-improvement (reference model, improvement process, and supporting artifacts) can be extended to improve any process. In this way, the approach can be directly applied to improving software acquisition processes.

Traditionally, implementing such an approach has been done as an on-the-fly activity by the process-improvement practitioners charged with upgrading the organization's processes. A need exists for a more rigorous and integrated approach to process improvement, especially for software acquisition process improvement. This approach must also include a roadmap to say what, when, and how to improve. It is the intent of the Software Acquisition

Improvement Framework to integrate all of those facets into a coherent approach for acquisition process improvement.

1.3 Overview of the Software Acquisition Improvement Framework (SAIF)

In the following subsections, the Software Acquisition Improvement Framework (SAIF) is described in terms of its architecture, operational use, and potential uses.

1.3.1 SAIF Architecture

The SAIF is a computer-aided system that ties together a process reference model, a disciplined improvement process, and a repository that contains the guidance and artifacts supporting the use of the reference model and improvement process. The SAIF architecture consists of these three elements, linked together to be mutually supportive.

The architecture of the SAIF has been generalized to allow it to accommodate alternative process-reference models and alternative improvement processes, while it maintains a consistent view for the user. The SAIF ultimately is intended to be a computer-based tool set that supports the work of acquisition professionals; this generalized architecture allows the SAIF to evolve from a paper-based to a computer-based form. The architecture also allows the SAIF to accommodate reference models and improvement processes outside of the acquisition domain. For example, the SAIF could employ software risk evaluations or domain analyses as a basis for reference models.

1.3.2 Operational Use

The SAIF presents an organization with guidance, methods, "how-to" practices, and other artifacts from a repository (technology catalog). These methods, practices, and other artifacts guide the organization through the steps of process improvement and allow the organization to select and adapt the practices that will improve the process.

The guidance and artifacts used are those appropriate to the current phase of the improvement process[1] and those appropriate to the areas of the reference model that allow the organization to plan and implement improvements. For example, if the organization needs to improve a particular area of its acquisition process, such as solicitation planning, and execution, the SAIF presents, from the repository (technology catalog), the guidance and alternative how-to practices appropriate to that area.

[1] See the IDEAL model for definitions of phases for the improvement process.

1.3.3 Uses

We anticipate that an organization will use the SAIF to do the following:

- Guide the organization's improvement process to a particlar maturity level of improvement.[2]
- Diagnose process capability and performance.
- Analyze where improvements are needed.
- Set goals and priorities for the improvement activities.
- Define process changes or additions to process capabilities.
- Identify which technologies are needed for improvement.
- Plan the insertion of technologies into the organization, implement this insertion, and obtain feedback on the results.

[2] See CMM definition for maturity level.

2. SAIF Conceptual Architecture Definition

This section defines the SAIF, its generic architecture, and the planned initial implementation of this architecture. The definition of the SAIF and its architecture are derived from the general operational requirements described in Appendix A.

2.1 Definition

The *Software Acquisition Improvement Framework* is an extensible system consisting of a disciplined process for improvement, a reference model, and supporting artifacts, all of which are integrated to be mutually supportive and to facilitate the improvement of an acquisition process.

2.2 Generic Architecture

Figure 1 shows the three components of the framework: process for improvement, reference model, and repository (technology catalog).

2.2.1 Reference Model

The *reference model* component of the framework allows the user to choose among reference models, which will be used to measure process-improvement success. Every process-improvement effort must include a standard that can be used to determine the effort's status—a diagnostic reference that characterizes the quality of the process to be improved and that can be used to measure the progress of the improvement. The SAIF architecture allows for a variety of reference models that can provide the characteristics of desired practices. The reference model answers the question, "Where am I?" by allowing a comparison between the organization's acquisition processes and those defined in the reference model. The reference model also answers the question, "Where do I need to go?" by defining the characteristics of desired processes, which may be used as goals for a process-improvement effort.

2.2.2 Process for Improvement

The *process for improvement* component of the framework allows the user to choose among process-improvement approaches. The SAIF architecture allows for a process that defines the set of steps and activities to be performed in the improvement effort. This process answers the question, "When and what route do I take to improve?" by defining the steps to be accomplished in improvement and the activities within each step. Alternate improvement processes are discussed in Appendix B.

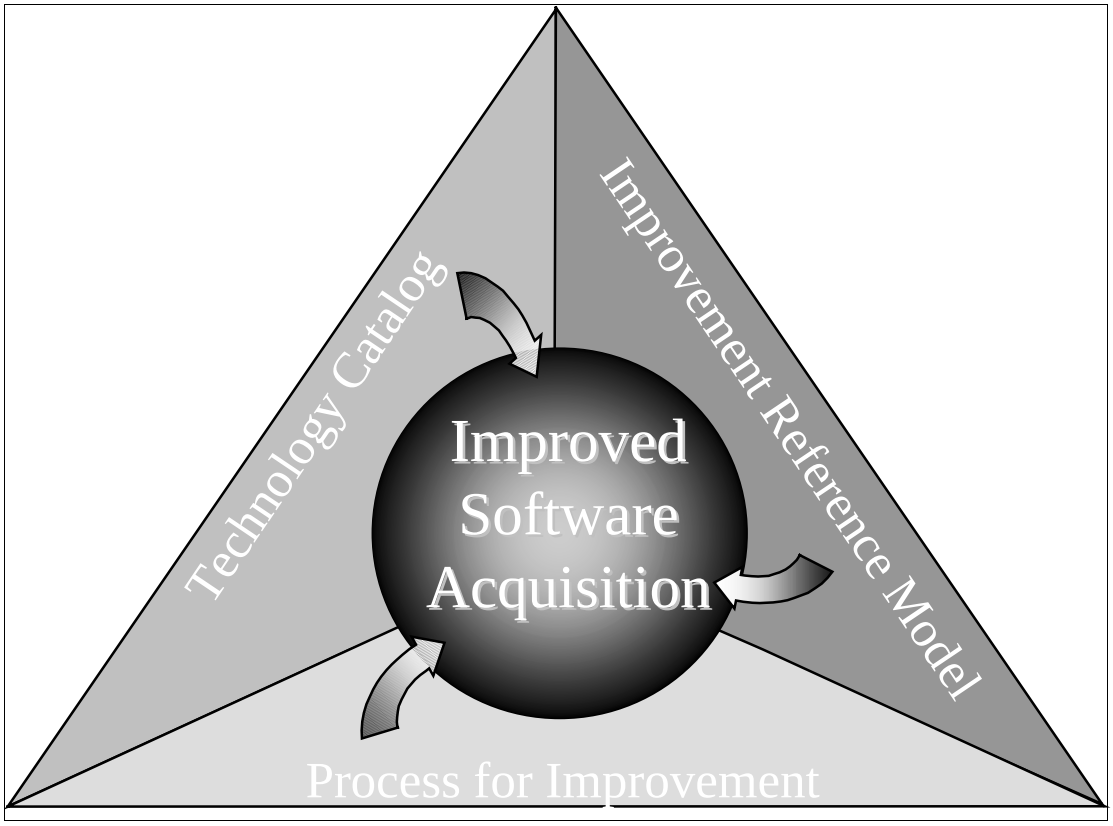

Figure 1: SAIF Architecture

2.2.3 Technology Catalog

The *technology catalog* component of the framework provides technology, in the form of both guidance and practices, to the user in support of process improvement in the organization. Every process-improvement effort must have the appropriate technical practices ("how to's") ready for insertion into the improvement effort at the appropriate time. The technology catalog is a repository of guidance and practices for process improvement, organized by the categories and steps of the reference model and the improvement process.

The artifacts or supporting technologies aid the application of the framework to the improvement effort. These artifacts and technologies include both processes and products (e.g., generic templates, guidance, and training packages). Templates include generic plans and policies that must be tailored to a specific environment to support improvement. Through these artifacts, the framework provides a mechanism for addressing the needs of the software acquisition community by disseminating and sharing guidance, experience, knowledge, and artifacts related to technology adoption. The technology catalog answers the important question, "How have others done this?" by cataloging practices based on experience. By providing alternative practices within practice areas, the technology catalog provides the user with options that can be chosen to optimize the process-improvement effort for the organization, the culture, and the work.

2.3 Planned Implementation

The SAIF architecture is initially instantiated with the following elements:

2.3.1 The Software Acquisition Capability Maturity Model (SA-CMM)

Figure 2 illustrates the SA-CMM as the improvement reference model. The SA-CMM is a staged capability maturity model exhibiting levels of maturity that an organization can achieve by effectively implementing processes to accomplish the activities and common features described in the model. In terms of the SAIF, the model is used as a basis to determine the current process capability of an organization relative to acquisition and to establish a set of goals for improvement. The model depicted in Figure 2 encompasses 5 maturity levels and 16 key process areas (KPAs). As the maturity level increases, the quality of the process is improved. For a further description of the SA-CMM refer to CMU/SEI-96-TR-020 [Ferguson 96].

Level	Focus	Key Process Areas	
5 Optimizing	***Continuous process improvement***	**Acquisition Innovation Management** **Continuous Process Improvement**	**Quality** **Productivity**
4 Quantitative	***Quantitative management***	**Quantitative Acquisition Management** **Quantitative Process Management**	
3 Defined	***Process Standardization***	**Training Program** **Acquisition Risk Management** **Contract Performance Management** **Project Performance Management** **Process Definition and Maintenance**	
2 Repeatable	***Basic Project Management***	**Transition to Support** **Evaluation** **Contract Tracking and Oversight** **Project Management** **Requirements Development and Mgmt.** **Solicitation** **Software Acquisition Planning**	**Risk** **Rework**
1 Initial	***Competent people and heroics***		

Figure 2: Software Acquisition Capability Maturity Model

2.3.2 The IDEAL Model

The IDEAL model serves as the improvement process for the first instance of the SAIF and is mapped into acquisition-specific steps for inclusion in the SAIF technology catalog. The IDEAL model shown in Figure 3 consists of five phases organized to provide a structured approach to process improvement and adoption of technologies to support process improvement. The continuous loop through the steps is an indication that this process can be, and usually is, a continual process. The length of time it takes to complete a cycle through

the model will vary from organization to organization, the improvements planned, and the resources available. Depending on the resources, many of the steps or activities may occur in parallel. In addition the model can be tailored to each organization's environment and constraints for process improvement.

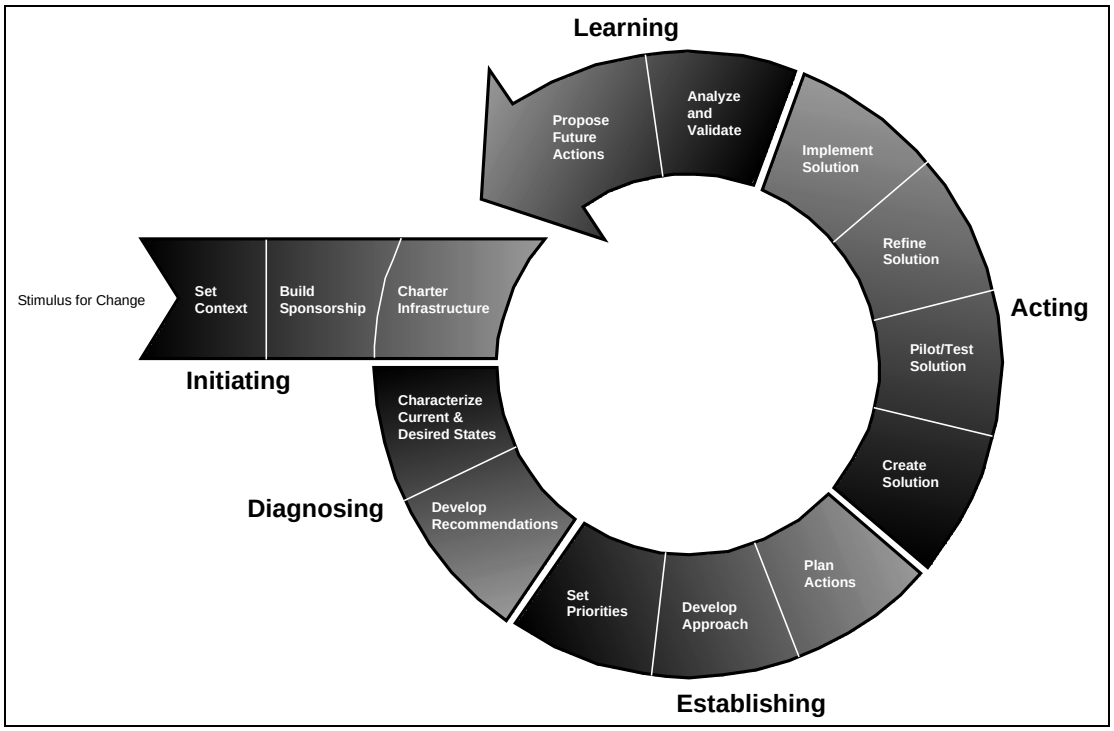

Figure 3: The IDEAL Improvement Process

2.3.3 The Technology Catalog

The Software Acquisition Technology Catalog contains the both the artifacts, or references to artifacts (such as generic templates and other technologies) that support the implementation of IDEAL and those technologies that support process definition and improvement against the reference model. The catalog provides the "links" to the appropriate stages of the IDEAL model for implementation and to the specific areas of improvement identified by the reference model.

Where possible, each technology and artifact in the catalog will include associated data that supports the technology or artifact from the standpoint of technology adoption or technology insertion (for example, how was it used in the past, under what circumstances, what was the return on investment, and how did it fit into the business context of the organization). In most cases, the stored items in the catalog are references to more detailed descriptions of the technology to be applied. See Section 3 for a detailed description of the technology catalog.

3. Software Acquisition Technology Catalog

This section describes the Software Acquisition Technology Catalog (catalog) and how it is employed with the process and reference models of the framework.

3.1 Catalog Notional Structure

The Software Acquisition Technology Catalog is the pivotal component of the framework. It is a computer-aided, extensible repository. As depicted in Figure 4, this repository consists of a database and a database management system, which is accessed through a graphical user interface.

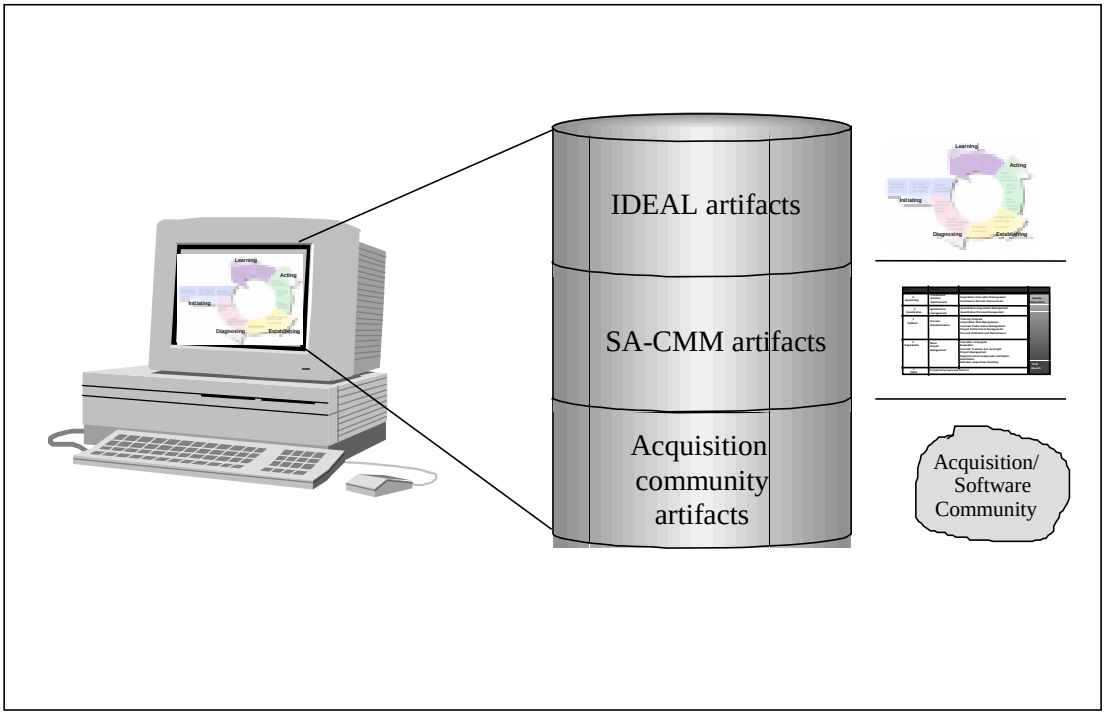

Figure 4: SAIF Notional Structure

The repository stores information (artifacts) that supports

- implementation and instantiation of a process improvement model such as IDEAL
- application of a reference model such as the SA-CMM
- other artifacts (e.g., guidance, “how-to” practices, and tools) that an organization may adapt to improve its software acquisition process

As new technologies that support the framework mature, these technologies are added to the repository as artifacts. In many cases, the stored artifacts are references to the more detailed description of the technology to be applied, along with an abstract of the technology.

Another perspective of the repository notional structure is shown in Figure 5, which illustrates how artifacts are categorized within the database. The artifacts may be stored by

- areas within the improvement reference model
- steps/sub-steps in the improvement process
- level of information —either guidance, practices, or applicable tools

Figure 5 uses example categories from the SA-CMM as a reference model, and IDEAL as a process improvement model. In practice, the categories will vary with the selected reference model and improvement process.

3.2 Catalog Levels of Information

The artifact information in the SAIF exists at three levels of abstraction: guidance, practices, and tools. While the demarcation line between these levels of information abstraction is not a hard-and-fast-boundary, the SAIF uses the following operational definitions:

Guidance: Information that tells the user *what* needs to be done and when it needs to be done. Guidance is at a higher level of abstraction than practices, and often establishes the need for practices by stating that the user should be doing an activity, without providing the details of how to do the activity. For example, guidance might state that the user should have a plan for risk management and that the plan should cover certain specified aspects of risk management.

Practice: Information that tells the user *how to* do an activity or set of activities within a process. Practices are more detailed than guidance and provide steps that a user can follow to accomplish the specified activity. An example of a practice might be a template plan for risk management, accompanied by tailoring guidelines.

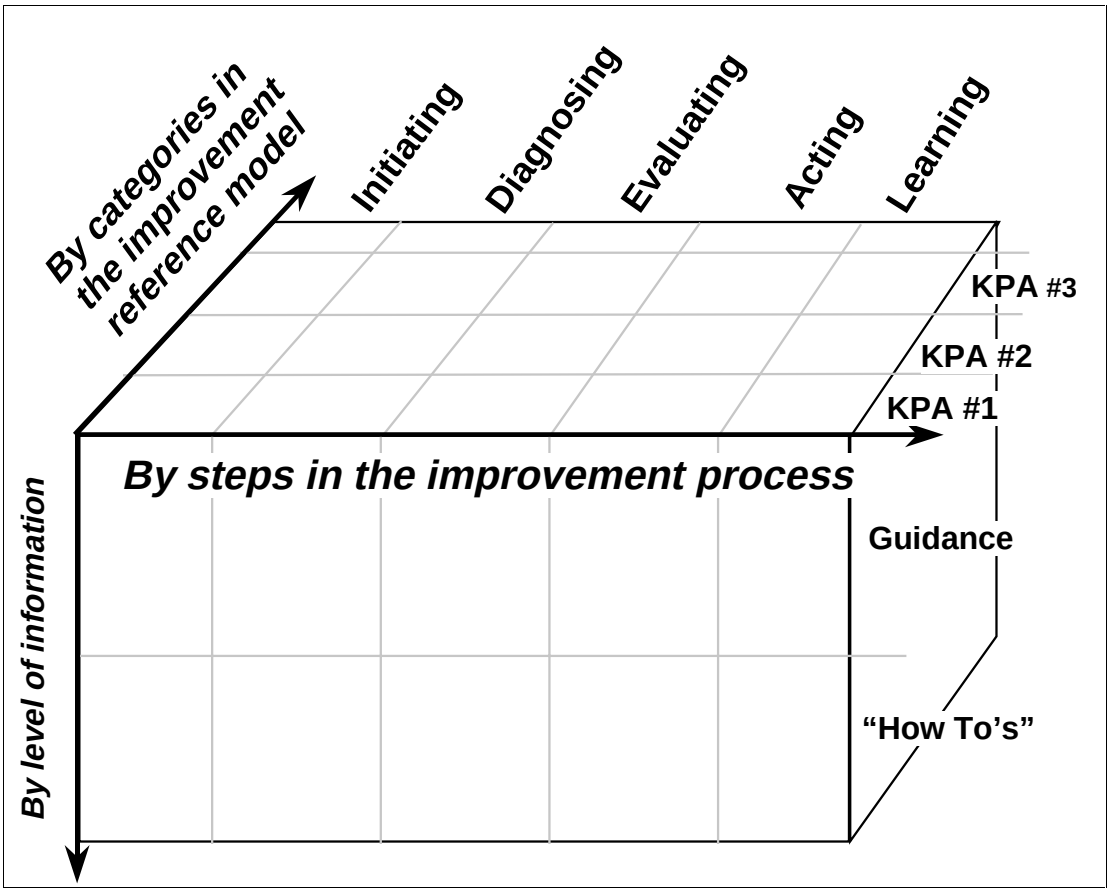

Figure 5: Organization of Artifacts in the SAIF

3.3 Artifact Information

In order for the SAIF to accomplish its goals, a consistent set of data for each artifact must be stored in the repository. The consistent set of data is captured in the criteria shown in Figure 6. These criteria are used to analyze the artifacts for inclusion in the repository and provide sufficient information for the SAIF to be used. Detailed explanation of these criteria is given in Appendix C.

3.4 Repository Linkages

For the initial instantiation of the SAIF, the catalog provides the "linking" of all artifacts residing in the catalog to the appropriate place within the IDEAL cycle and to specific key process areas (KPAs) of the SA-CMM. Properly employed by an acquisition organization, its intended use is to identify those artifacts that are needed to implement the reference model, support implementation of the improvement process, and provide the artifacts to support the organization's process improvement.

Table 1 illustrates a small sample of the data stored and shows how these technologies are related to the phases of the IDEAL model and KPAs of the SA-CMM. (The table does not indicate the actual data structures or schema used in the repository.)

Name of practice
Description of practice
Purpose
Process areas Applicable common features
Acquisition life-cycle phase
Resources

Usage/limitations
Pros
Cons
Origin (optional)
Supporting tools, techniques, and technologies
Recommendations for change
Reference, information sources, point of contact
Last modified

Acceptance/Quality Criteria
Software-intensive systems acquisition domain Legal and regulatory compliance Well documented Maturity/successful application history Overall return on investment External reviewers/evaluators

Figure 6: Minimum Descriptive Information and Criteria for SAIF Artifacts

3.5 Catalog Query Program

In addition to storing artifacts, the catalog includes a second component—an interactive query program that guides users through the framework. By answering questions, the users can focus on appropriate artifacts to support their improvement needs.

Based on use of the IDEAL and SA-CMM instantiation of the SAIF, the operational use of the catalog would be to query the repository, "sorting" on the phase of the improvement process and reference model links to specific key practices and whether guidance, practices, or tools were desired. The response would provide the user a listing of all the information sources that satisfy the query by title. Subsequent query of these sources would provide the user information stored for that artifact such as the information shown in Figure 6 above.

SAIF Improvement Process Phase →		**1**	**2**	**3**	**4**	**5**	**Links to SA-CMM KPAs**
Artifacts (Technologies)							
Process models							
	IDEAL technical reference model: CMU/SEI-96-HB-001	x	x	x	x	x	
	IDEAL implementation guidelines and templates	x	x	x	x	x	
Reference model							
	SA-CMM (CMU/SEI-96-TR-020)	x	x				
	SA-CMM appraisal process		x				
	SA-CMM familiarization kit	x					
	SA-CMM Maturity Questionnaire	x					
Tech transition training & assistance							
	SEI Open Systems						
	Intro. to SA-CMM						
	CBA lead assessor						
“how-to” technologies							
	SA-CMM policy templates			x			All SA-CMM KPAs
	SA-CMM planning templates			x			All SA-CMM KPAs
	Reuse engineering			x			
	Team risk management			x	x		
	Software Risk Evaluations		x	x	x		

Table 1: Notional Concept of Technology Catalog Linkages

Queries are effected through a windowing, graphical user interface that transparently provides the user the necessary search (query) mechanism to access the data.

Figure 7 provides a notional concept of operations, which will be discussed in Section 4. Here the user requests information on guidance and practices. The technology catalog provides a perspective from the reference model or from the improvement process of the artifacts that support these points of view.

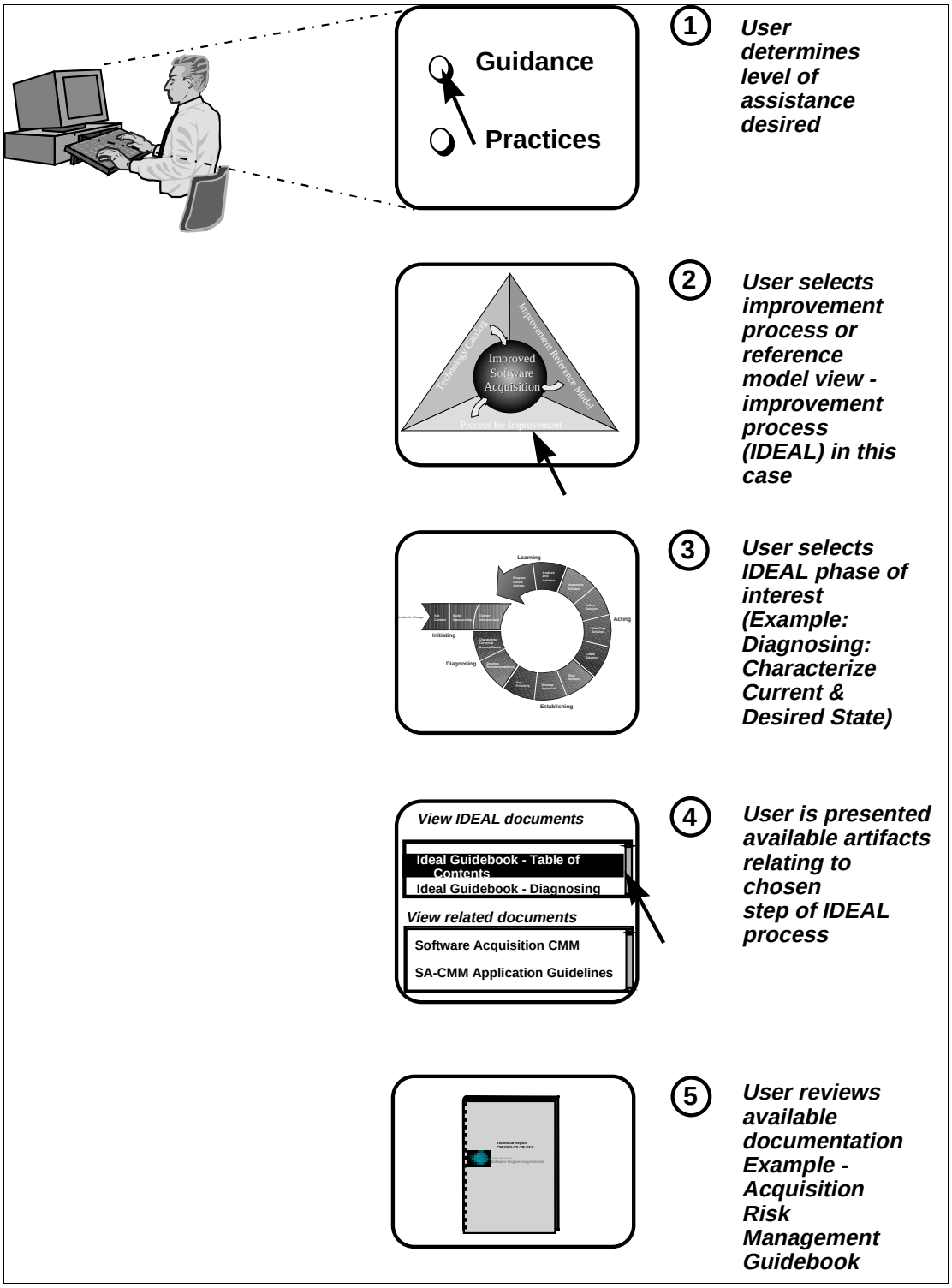

Figure 7: Use of the Automated Technology Catalog

4. Intended Operational Use of the SAIF

This section describes how the Software Acquisition Improvement Framework (SAIF) is intended to be applied, by stepping through the phases of the IDEAL model, as an example, and indicating at what points the reference model and technology catalog come into play.

To apply the framework, the acquisition organization follows the steps described in the IDEAL model, employing appropriate artifacts from the catalog. Because IDEAL is a general model, the organization may need to tailor its activities and scheduling of the steps to its specific environment or circumstances. (For example, an organization may have already been diagnosed and know areas for software acquisition improvement. In this case, the initial and diagnostic phases of the IDEAL model may be passed over.) Here, the supporting artifacts from the technology catalog are the description of the IDEAL model and tailoring guidelines to alter activities and procedures for each phase of this model. The catalog indicates these items linked to this tailoring. Following this initial tailoring, the organization proceeds through the appropriate IDEAL phases as described below.

4.1 Initiating Phase

The initiating phase is the starting point of the process. This is where the stimulus for improvement is generated. This stimulus could take many forms, but typically, it occurs when senior management first understands the need for improving the acquisition process. This phase also is where the context of the improvements is documented, derived from the business or enterprise goals of the organization. The initial infrastructure to conduct the improvement program is established, the role and responsibilities for the infrastructure are defined, and initial resources are assigned. This latter statement implies that there is a commitment from senior management to improve its software acquisition process—a crucial requirement for beginning this process. An initial plan is developed to baseline the need for improvement and set up the infrastructure.

Example artifacts that support the IDEAL implementation in this phase are the IDEAL model technical reference, the detailed IDEAL procedures to be followed in this phase, and a template for the plan.

Artifacts that support the instantiation of IDEAL for acquisition include the SA-CMM and its supporting artifacts, which include the SA-CMM familiarization kit and SA-CMM application guidelines.

4.2 Diagnosing Phase

In the diagnosing phase, the organization starts on the path to continuous improvement of it software acquisition process. This phase lays the ground work for the remaining phases. In this phase, appraisal activities are usually performed to establish the organization's process maturity baseline. (The maturity baseline is the result of using the SA-CMM as the reference model.) The results and recommendations from the appraisals and any other baselining activities will be reconciled with existing and/or planned improvement efforts for inclusion into an acquisition process improvement plan. (see Section 4.3, Establishing Phase).

An artifact that supports the IDEAL implementation in this phase is the IDEAL model technical reference [McFeeley 96].

Artifacts that support the instantiation of IDEAL for acquisition include the SA-CMM and its supporting products, which include the following:

- SA-CMM application guidelines
- Appraisal methodology associated with the SA-CMM (CMM-Based Appraisal for Internal Process Improvement [CBA IPI])
- Introduction to the SA-CMM training course
- Lead assessor training course for CBA IPI

Results of an SA-CMM appraisal are provided to senior management to garner or sustain their support to continue with the improvement initiative. The documented results would also be additional input to the improvement plan initially developed during the initiating phase.

4.3 Establishing Phase

During this phase, an improvement plan, which is a continuation of the plan developed during the initiating phase, is generated in accordance with the organization's vision, enterprise goals, strategic plan, and lessons learned from past improvement efforts. Senior management considers the areas that need to be improved and decides which areas to implement, again based upon improvement needs, available resources, and other organizational policies and constraints.

The improvement areas that the organization has decided to address with its improvement efforts are prioritized, and strategies for pursuing the solutions are developed. The draft of the action plan will be completed in accordance with the organization's vision, strategic plans, lessons learned from past improvement efforts, key business issues, and long-range goals. During this phase, measurable goals or objectives for the improvement effort are developed from the general goals developed in the initiating phase. Measurements will be developed to monitor progress of the improvement initiative. Finally, resources are committed and training necessary to carry out the planned improvement effort is accomplished.

In this planning effort, process-definition activities are carried out so that solutions can be applied to effect the necessary improvement. The supporting artifacts play heavily in this phase. This phase matches results from the diagnosing phase with technologies and artifacts that are believed to improve the overall acquisition process. In order to improve with respect to this model, the acquisition organization must modify or put into place a process, a set of processes, or other technologies and artifacts, to accomplish those activities and key features of the reference model, which had been identified as areas for improvement.

Using the SA-CMM as a reference, improvement is not simply a matter of introducing or modifying processes that accomplish all the activities or key features for that KPA. It may appear that the way to improvement is introducing the processes needed to master all the KPAs at one level and be in the range of the next level. Thus, if an acquisition organization masters all the KPAs at Level 2, then it should be at the beginning range of Level 3. However, it is not simple. The process or processes to be introduced must be considered in terms of value added, return on investment, and long-range goals before they are deployed. The selection of a new technology must also take into account any constraints facing the acquisition organization and, possibly, each project within that organization. The point is that introducing a technology—a new process, for example—for the sake of being rated higher against the SA-CMM reference, may not yield an improvement in the organization's performance. All aspects of introducing a technology must be considered, and the technology must be tailored to the organization's needs before introduction in order for the technology to be introduced successfully.

Artifacts that support the IDEAL implementation in this phase are the IDEAL model technical reference [McFeeley 96] and a template for the plan.

Artifacts that support the instantiation of IDEAL for acquisition include the SA-CMM , implementation guidelines for the SA-CMM (which includes templates for policies and plans called for in the SA-CMM), and all the "how-to" technologies in the catalog that are applicable to the planned areas of improvement.

For the "how-to" technologies, the catalog will, in most cases, reference the technology and its supporting artifacts. These "how-to" technologies are not necessarily focused on specific or distinct areas that may be identified by the SA-CMM; therefore, the "links" shown in the catalog will indicate the application of a technology to more than one area of improvement. Thus, the process designer must understand and apply these technologies to fit the needs of the organization (see the Section 4.4, Acting Phase).

4.4 Acting Phase

In the acting phase, solutions to address the areas of improvement defined in the preceding phases are developed and piloted. Lessons learned are collected, in addition to metrics on performance and goal achievement. These activities of collecting information on solutions are not confined to the solutions identified for improvement in previous phases. Past

improvement efforts may already be in place, and projects may have applied other acquisition techniques to their specific project. Information is collected on these efforts, as well.

In terms of the technologies and artifacts proposed in the establishing phase, the acting phase creates or “tailors” those proposed solutions to satisfy the organization’s needs. Some of the “how-to” technology artifacts will have associated guidance to help the designer tailor or otherwise adapt them to the needs of the organization.

An artifact that supports the IDEAL implementation in this phase is the IDEAL model technical reference.

4.5 Learning Phase

The objective of the learning phase is twofold. First, if solutions developed during the acting phase were successful or show promise for an improved acquisition process, these are included in the organization’s standard software acquisition process and are made available for use throughout the acquisition organization. Second, artifacts such as lessons learned and metrics on performance and goal achievement have been collected to make the next pass through the IDEAL model more effective. By this time, solutions have been developed. These are added to the organization’s repository, which will become the source of data for the next pass through the IDEAL model.

5. Summary

This section summarizes the concepts and describes implementation plans for the SAIF.

5.1 Definition and Planned Implementation

The SAIF is an extensible framework that assists organizations in improving their software acquisition capability. The framework consists of three elements:

- reference model for improvement- allows a choice among reference models against which process improvement can be measured
- process for improvement - allows a choice among process improvement approaches
- technology catalog - provides technology in the form of both guidance and practices, to support an organization in process improvement

Initially the implementation will use the following models:

- The Software Acquisition Capability Maturity Model (SA-CMM) will be used as a basis to determine the current capability of an organization relative to acquisition processes and to establish a set of goals for improvement.
- The IDEAL model will serve as the improvement process for the SAIF.
- The Software Acquisition Technology Catalog contains the artifacts, or references to artifacts, such as generic templates and other technologies, that support both the IDEAL model and the SA-CMM. The catalog provides the "links" to the appropriate stages of the IDEAL model for implementation of this model and to the specific areas of improvement that are identified by the reference model.

5.2 Future Work

Several efforts are needed to complete the SAIF implementation.

First, characteristics of the guidance and effective practices needed to support the IDEAL model and the SA-CMM must be defined. This characterization will allow the development of such artifacts or the elicitation of such artifacts for the inclusion into the technology catalog. The World Wide Web (WWW) is one mechanism that may be used to elicit such artifacts. Workshops and user needs analyses are planned to support the elicitation.

Second, the graphical user interface and the linking of the artifacts is to be accomplished with a database management system (DBMS) as part of the technology catalog. A second

possibility is to use the WWW. The decision on which to use depends upon the transition mechanism that would most benefit the user.

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Appendix A: General Operational Requirements for the SAIF

Organizations currently involved with the acquisition of software and software-intensive systems do not have the knowledge, technology, or motivation to improve their acquisition process. The purpose of the framework is to provide a disciplined approach supported by automation that helps organizations to improve their software acquisition process capability.

It is anticipated that an organization will use the framework to

- diagnose its software acquisition process capability
- analyze where improvements are needed
- define processes changes or additions to their capabilities
- set goals and priorities for improvement
- identify what technologies are needed for improvement
- plan introduction of these technologies into the organization
- implement this introduction and obtain feedback on the results of these technologies

General Requirements

The SAIF will provide an extensible framework that helps organizations to improve their software acquisition capability. (A framework is defined as a basic arrangement, form, system, or set of relationships. A framework may consist of data organized into a structure that gives insight into the practices and technologies that may constitute the framework.)

The SAIF will provide a structured methodology to appraise and identify technologies (both practices and products) employed to improve an organization's acquisition capability. Table 2 illustrates potential uses of the SAIF. There are no known systems that currently provide the structured methodology that is provided by the SAIF.

	SAIF Use	Description
1	Process guidance	Help define an organization's software acquisition capability and use as a motivational tool to improve the process(es) within the organization
2	Process capability appraisal	Provide an approved methodology to support capability appraisals to diagnose the organization's software acquisition process capability relative to a reference model
3	Acquisition process framework	Provide a mechanism to apply technologies (both practices and tools) that support and maintain continuous improvement and obtain feedback on the results of these technologies
4	Plan for improvement	Support planning the introduction of these technologies into the organization

Table 2: Employment of the SAIF

The SAIF is an overarching system that will be the integration mechanism for software acquisition products and technologies. It will focus these products and technologies on improving the organizations' acquisition processes.

Capabilities Required

The SAIF will

- provide a structured, disciplined process explaining step-by-step procedures for an organization to follow in order to initiate, diagnose, plan, implement, learn, and, thereby, manage the adoption of technologies (processes, products, tools, etc.) to improve its software acquisition process capability
- contain a repository of guidance and specific artifacts (or references to artifacts [technologies]) that support the disciplined approach to improve the software acquisition process
- be sufficiently flexible to accommodate upgrades in technologies for the SAIF itself
- provide a user-friendly interface in operation
- use an established reference model as a basis to determine process capability and process improvement opportunities
- provide automation tools to support the operation of the framework

- provide an automatic mechanism to allow the user to link repository artifacts that could be exploited to initiate, diagnose, plan, implement, learn, and, thereby, manage the adoption of technologies to exploit specific improvement opportunities identified by the SAIF
- store or reference “how-to” practices that can be used to implement the steps of or define the acquisition processes of an organization
- be designed to accommodate alternative reference models and improvement processes
- use personal computer technology to implement the automated portion of the system
- contain reference to technologies that support the process improvement
- require no direct interface to other systems other than reference links to these technologies stored in the repository
- link technologies to appropriate improvement areas within the improvement reference model
- be maintained initially by the Software Engineering Institute (SEI)
- include training for operation of the SAIF

Appendix B: Alternative Improvement Processes

The SAIF architecture was developed to be general in nature. It does not presume a particular reference model for the software acquisition process, nor does it assume a particular process for improvement. This generalization was used to allow future selection of a reference model and an improvement process from among viable candidates that may exist. Allowing for alternative reference models and improvement process models requires that the SAIF be configured (instantiated) for the chosen models. This would require a change to the technology catalog to incorporate the correct links from the technologies stored to the reference and process models.

Example Reference Models

For example, one might select the Software Acquisition Capability Maturity Model as the reference model. (This model has the structure shown in Figure 8.) The implication is that the information in the SAIF—guidance and practices that define "how-to" information for improvement—will then be organized around the categories of the reference model. Thus we would see information categories such as

- key process areas (16 defined areas)
- activities (96 defined within the 16 key process areas)
- metrics (one per key process area)
- verification (two per key process area)

A user of the SAIF would access information according to categories defined by the reference model. If he or she were interested in the project management area, information would be accessed by that key process area (KPA) and by the activity, metric, or verification practice within that KPA.

Level	Focus	Key Process Areas	
5 Optimizing	*Continuous process improvement*	Acquisition Innovation Management Continuous Process Improvement	Quality Productivity
4 Quantitative	*Quantitative management*	Quantitative Acquisition Management Quantitative Process Management	
3 Defined	*Process Standardization*	Training Program Acquisition Risk Management Contract Performance Management Project Performance Management Process Definition and Maintenance	
2 Repeatable	*Basic Project Management*	Transition to Support Evaluation Contract Tracking and Oversight Project Management Requirements Development and Mgmt. Solicitation Software Acquisition Planning	
1 Initial	*Competent people and heroics*		Risk Rework

Figure 8: SA-CMM Structure

If the user had a reference model with seven practice areas, such as the Software Program Managers' Network (SPMN's) Best Practices Framework [SPMN 98], the categories of information would be defined by that model. Those categories would be

- risk management
- requirements management
- planning and tracking
- quality
- interface management
- project stability
- project-unique issues

Other reference models that may be used include the System Engineering Capability Maturity Model (SE-CMM), the SPICE (Software Process Improvement Capability Determination) model, and the SDCE (Software Development Capability Evaluation) model.

Example Improvement Processes

Alternative improvement processes are supported by the SAIF architecture, in order to provide adaptability to a variety of process improvement approaches.

One example of an improvement process is the Plan-Do-Check-Act (PDCA) model, attributed to Shewart. This model is shown in Figure 9 below.

Using this model, the SAIF would organize the applicable technologies and guidance material into the following categories:

- plan phase
- do phase
- check phase
- act phase

This organization allows the user to focus on the phase of process improvement in which he or she is interested, and find guidance and practices appropriate to that phase of the program.

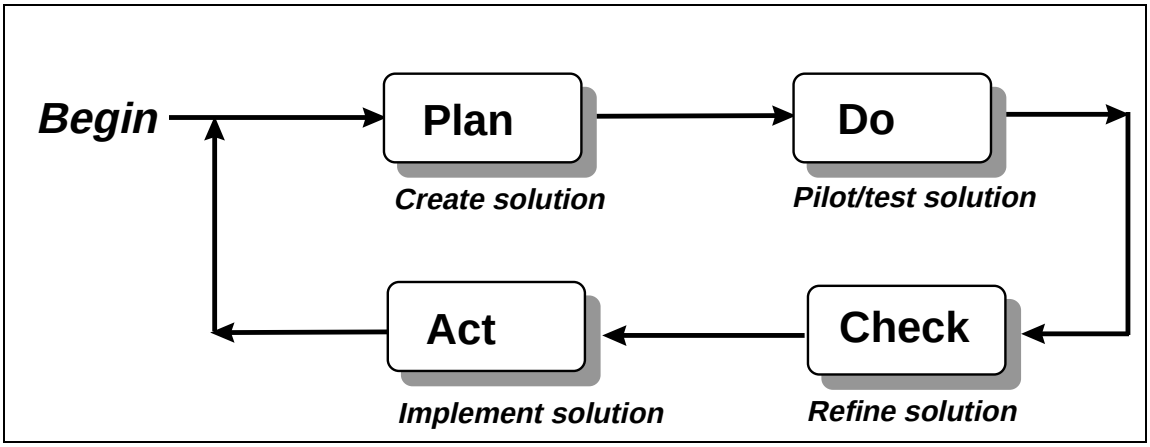

Figure 9: Plan-Do-Check-Act Model for Process Improvement

SEI's IDEAL model for process improvement, shown in Figure 10, would represent an alternative improvement process.

Using the IDEAL model as the chosen improvement process would yield the following information categories, organized around the IDEAL model:

- initiating phase
- diagnosing phase
- establishing phase
- acting phase
- learning phase

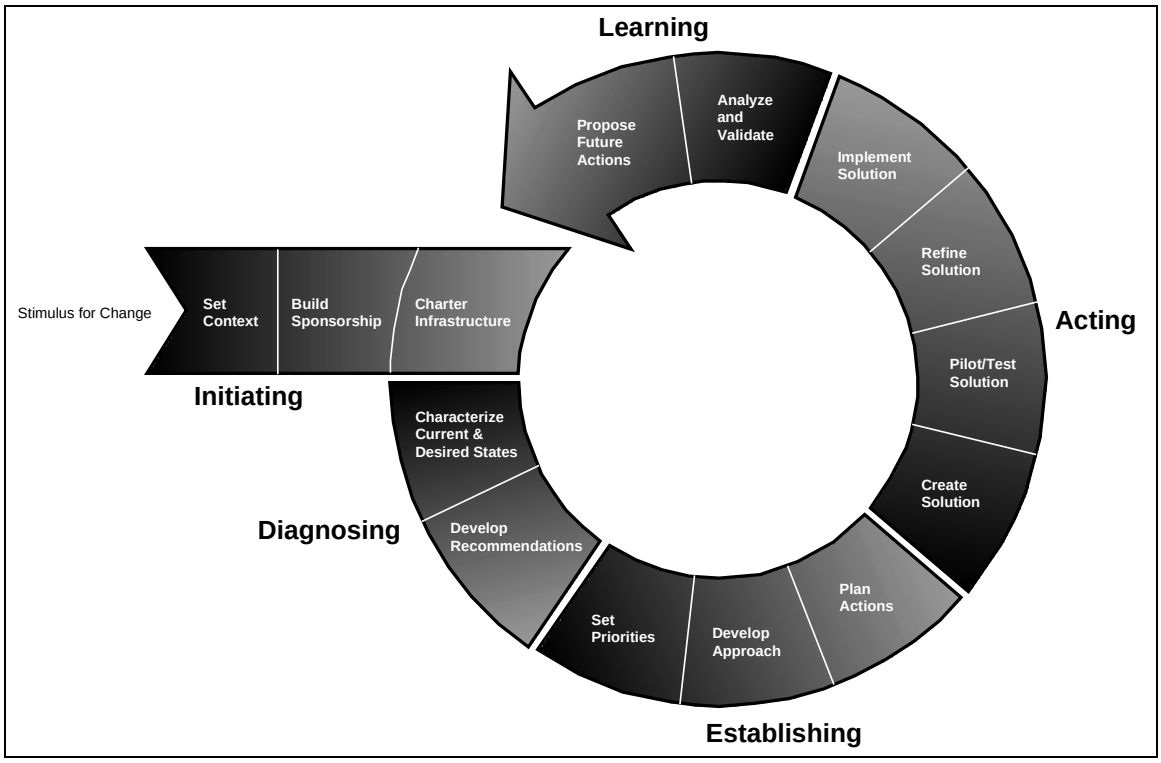

Figure 10: IDEAL Model

Appendix C: Criteria for Judging "Effective" Acquisition-Management Practices

Name of Practice: Brief nomenclature, if available. It is important to distinguish between a practice and guidance. For our purposes, we define a *practice* as a customary or established way of performing an activity or a set of activities; an "effective" practice is a customary way that results in the timely accomplishment of goals supported by the activity within a desired cost range. Note that one goal may be supported by several activities or practices. Goals toward process improvement are dependent on the domain and reference model chosen. The distinction between a *process* and a *practice* is as follows: a process describes a set of activities performed for a given purpose (or "what" to do), while a practice describes "how" to do an activity or a set of activities within a process.

Description of Practice: Brief abstract describing the practice. This description is especially needed if the practice does not have an accepted name or nomenclature outside of the user's domain. This description answers the questions, "What does the practice do?" and "How is the practice performed?"

Purpose: Answers the questions "Why is the practice needed?" and "Who uses the practice?"

Process Areas: Process areas where the practice is applicable (where does it fit in a given reference model?); applicable SA-CMM KPAs and activities will be the reference model of choice. Later, an acquisition-instantiated version of the IDEAL model might be used or possibly the IEEE Recommended Practice for Software Acquisition process areas; possibly Software Program Managers' Network (SPMN) Best Practices.

Functional Domain: Functional domain(s) where the practice is applicable from the following eight Government acquisition discipline areas: acquisition management, system engineering, software acquisition management, test and evaluation, manufacturing and production, acquisition logistics, business/cost estimating and financial management, and contract management.

Acquisition Life-Cycle Phase: Life-cycle phase(s) where the practice is applicable from the following five areas: Pre-Milestone 0; Concept Exploration or Phase 0; Program Definition

and Risk Reduction or Phase I; Engineering and Manufacturing Development or Phase II; Production, Fielding/Deployment, and Operational Support or Phase III.

Resources: Extraordinary resources required to implement the practice; includes costs, people, skills/training requirements, environmental or domain constraints, functional interfaces, etc.

Usage/Limitations: Provides the context for proper use of the practice including any limitations on its use. If the practice has security or proprietary limitations, document the practice as much as allowed and indicate the limitation here. Note: we assume the practice is oriented toward process improvement.

Pros: Any advantages of applying the practice within the scope of its intended use (i.e., known positive effects from adopting the practice).

Cons: Any disadvantages of applying the practice within the scope of its intended use (i.e., known negative effects from adopting the practice).

Origin (optional): Original source or brief background of the practice, if known. If the practice is already universally accepted as "effective," what criteria were used or what evolution occurred to make it "effective"?

Supporting Tools, Techniques, and Technologies: Tools, techniques, and /or technologies that support the practice, if any; the prerequisite technologies that allow the practice to be implemented efficiently. A supporting technology for one practice could be a practice in its own right (e.g., Earned Value Management System [EVMS] is a practice supported by several software tools, one of which is wInsight; the wInsight tool is a practice in itself for cost and schedule project management).

Recommendations for Change: Any known existing recommendations for future modifications, tailoring, or extensions of the practice.

Reference, Information Sources, Point of Contact: Documentation and bibliographic information or link to information sources. Also include current point of contact for the practice if different from information source.

Last Modified: Date on which this practice description was last modified, if known. Estimate if unknown and indicate the date is an estimate.

Acceptance/Quality Criteria: Description of the criteria that are used to judge the successful application and general acceptance of the practice by the acquisition community. Criteria below must be objective and verifiable:

- **Software-intensive systems acquisition domain:** Practice must fit into the chosen reference model defined above (i.e., SA-CMM).
- **Legal and regulatory compliance:** Practice must comply with applicable laws and regulations within the functional domain (e.g., federal acquisition regulation [FAR] for DoD, ISO, standards, etc.).
- **Well documented:** Unambiguous understanding based on practice description and supporting documentation; documentation defines goals, steps, tasks, activities, inputs, outputs, measurements, and verification required.
- **Maturity/successful application history:** Describe how welldeveloped and understood the practice is; give past and present projects or efforts where the practice has been successfully used and points of contact for each successful project. A mature practice usually implies successful application on several projects or efforts each over a significant timeframe.
- **Overall return on investment (ROI):** Practice incorporates a way of realizing a return on investment that can be measured or equated to a positive long-term goal (e.g., dollars saved, increased productivity, increased quality of product or service, increased morale). A practice may require a short-term cost growth that results in a long-term cost savings, so ROI should be interpreted with the overall life cycle of the project or effort in mind.
- **External reviewers/evaluators:** Names of experts who have reviewed the practice description and evaluated the practice.

Note: The SEI Technology Reference Guide Quality Measures Taxonomy contains additional criteria that may be applicable as well [Foreman 97].

Example Using Continuous Risk Management

Name/Description of Practice: Continuous Risk Management

Purpose: A paradigm for managing project risks

Process Area/ Functional Domain/Acquisition Life Cycle: All

Resources: CRM training for implementers

Usage/Limitations: Nothing significant. Security environments may impede open communications.

Pros/Cons

Pros: Better understanding and mitigation of project risks

Cons: Time investment required to get up to speed

Origin: SEI/CMU Risk Program; documented in CRM Guidebook published Sept. 1996

Supporting Tools, Techniques, and Technologies: Documented in appendices of CRM Handbook which collectively support the paradigm

Recommendation for Change: CRM is flexible and adaptable, typically tailored to an organization's processes and procedures; recommended changes are collected by the SEI for the next edition of the Guidebook.

Reference, Information Sources, Point of Contact: See bibliography in the CRM Guidebook.

Point of Contact: Ray Williams, SEI/CMU, phone 412-268-7614

Last Modified: One publication so far in Sept 1996

Acceptance/Quality Criteria:

Applicable to Project Management and Acquisition Risk Management KPAs of SA-CMM. No regulatory limitations. Well documented in guidebook; training available. Successful application on a limited number of projects given recent paradigm introduction. ROI is dependent on specific application and implementation of ROI metrics within project. CRM Guidebook authors and project personnel act as internal reviewers; the guidebook lists experts outside the SEI who served as external reviewers (Charette, Hall, etc.).

Glossary

acquisition	The process of obtaining through contract.
acquisition organization	That entity that has the oversight responsibility for the software acquisition project and that may have purview over the acquisition activities of a number of projects or contract actions.
capability maturity model	A description of the stages through which organizations evolve as they define, implement, measure, control, and improve their processes. The model provides a guide for selecting process improvement strategies by helping an organization to determine its current process capabilities and identify the issues most critical to quality and process improvement.
process	A set of activities performed for a given purpose (e.g., the software acquisition process).
process capability	The range of expected results that can be achieved by following a process. (See *process performance* for contrast.)
Software Acquisition Improvement Framework	A system consisting of a disciplined process for improvement, a reference model, and supporting artifacts that are integrated to be mutually supportive and facilitate the improvement of an acquisition process.
software acquisition process	A set of activities, methods, practices, and transformations that people use to acquire software and the associated products. *acquisition organization's standard software acquisition process* - The acquisition organization's fundamental software acquisition process that guides the establishment of each project's defined software acquisition process. *project's defined software acquisition process* - The project's tailored version of the acquisition organization's standard software acquisition process.

software acquisition project	An undertaking that is focused on acquiring the software components and associated documentation of a system. A software project may be part of a project building a hardware/software system.
software acquisition-related group	A collection of individuals (both managers and technical staff) representing a software discipline that supports, but is not directly responsible for, software acquisition. Examples of software disciplines include software configuration management and software quality assurance.
software architecture	The organizational structure of the software or module [IEEE-STD-610].
software-related contractual requirements	All technical and nontechnical requirements related to the software portion of the acquisition.
software support	The process of modifying a software system or component after delivery to correct faults, improve performance or other attributes, or adapt to a changed environment [IEEE-STD-610].
solicitation package	Information distributed when seeking suppliers for a particular acquisition. This package describes to interested bidders what the requirements are, how to prepare their proposals, how proposals will be evaluated, and when to submit their proposals. It is sometimes called a request for proposal (RFP).
traceability	The ability to trace, in both the forward and backward directions, the lineage of a requirement from its first-level inception and subsequent refinement to its implementation in a software product and the documentation associated with the software product.

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The Software Acquisition Improvement Framework (SAIF) is a computer-aided system that supports the improvement of an organization's software-acquisition process capability and performance. The framework integrates an acquisition-process reference model, such as the Software Acquisition Capability Maturity Model℠ (SA-CMM®); a process that defines the improvement approach, such as the SEI's IDEAL℠ method; plus guidance and other artifacts, which support the use of the model and improvement process. The guidance and artifacts are stored in a repository that automatically links them to the rest of the framework. This linking is structured to ensure that the reference model, the improvement process, and the supporting artifacts are available to the organization at the right time in the improvement process phases and to focus on the areas for which the organization seeks improvement. This document discusses rationale behind the need for the SAIF, the elements constituting the SAIF, and the intended operational usage of the SAIF.

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