Task/Subtask IV02.1
CDRL Sequence A014–003
16 January 1995

SOFTWARE TECHNOLOGY FOR ADAPTABLE, RELIABLE SYSTEMS (STARS) PROGRAM

Technical Papers: Software Process Framework, Tool to Determine Consistency With the CMM

Contract No. F19628–93–C–0129
Task IV02 – Megaprogramming Transition Support

Prepared for:

Electronic Systems Center
Air Force Materiel Command, USAF
Hanscom AFB, MA 01731–2116

Prepared by:

Loral Federal Systems
700 North Frederick Avenue
Gaithersburg, MD 20879

Cleared for Public Release, Distribution is Unlimited

Task/Subtask IV02.1
CDRL Sequence A014-003
16 January 1995

SOFTWARE TECHNOLOGY FOR ADAPTABLE, RELIABLE SYSTEMS (STARS) PROGRAM

Technical Papers: Software Process Framework, Tool to Determine Consistency With the CMM

Contract No. F19628–93–C–0129
Task IV02 – Megaprogramming Transition Support

Prepared for:

Electronic Systems Center
Air Force Materiel Command, USAF
Hanscom AFB, MA 01731–2116

Prepared by:

Loral Federal Systems
700 North Frederick Avenue
Gaithersburg, MD 20879

REPORT DOCUMENTION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*

2. REPORT DATE
1/16/95

3. REPORT TYPE AND DATES COVERED
Informal Technical Report

4. TITLE AND SUBTITLE
Software Process Framework, Tool to Determine Consistency With the CMM

5. FUNDING NUMBERS
F19628-93-C-0129

6. AUTHOR(S)
Paul G. Arnold, Loral Federal Systems - Gaithersburg
William H. Ett, Loral Federal Systems - Gaithersburg
S. Wayne Sherer, STARS DPM (Army)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Loral Federal Systems
700 North Frederick Avenue
Gaithersburg, MD 20879

8. PERFORMING ORGANIZATION REPORT NUMBER
A014-003

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Electronic Systems Center/ENS
Air Force Materiel Command, USAF
5 Eglin Street, Building 1704
Hanscom Air Force Base, MA 01731-2116

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
N/A

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Cleared for Public Release, Distribution is Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This paper presents the results and lessons learned from trial usage of the Software Engineering. Institute's (SEI) Software Process Framework (SPF). The SPF was used to check consistency of the Cleanroom Software Engineering (CSE) process against the SEI Capability Maturity Model (CMM) for Software. The trail usage was done for a STARS Software Technology for Adaptable, Reliable Systems) supported software development project, Improved Mortar Ballistic Computer (IMBC), at the US Army's Picatinny Arsenal Life Cycle Software Engineering Center (LCSEC).

14. SUBJECT TERMS
Software Process Framework (SPF), STARS, Tool, Capability Maturity Model (CMM)

15. NUMBER OF PAGES
46

16. PRICE CODE
N/A

17. SECURITY CLASSIFICATION OF REPORT
Unclassified

18. SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

19. SECURITY CLASSIFICATION OF ABSTRACT
Unclassified

20. LIMITATION OF ABSTRACT
SAR

Preface

This document was developed by the Loral Federal Systems - Gaithersburg, located at 700 North Frederick Avenue, Gaithersburg, MD 20879. Questions or comments should be directed to Paul Arnold at 301-240-7464 (Internet: pga@sei.cmu.edu).

This document is approved for release under Distribution "A" of the Scientific and Technical Information Program Classification Scheme (DoD Directive 5230.24).

The contents of this document constitutes technical information developed for internal Government use. The Government does not guarantee the accuracy of the contents and does not sponsor the release to third parties whether engaged in performance of a Government contract or subcontract or otherwise. The Government further disallows any liability for damages incurred as the result of the dissemination of this information.

Software Process Framework, Tool to Determine Consistency With the CMM

Paul G. Arnold, Loral Federal Systems
William H. Ett, Loral Federal Systems
S. Wayne Sherer, STARS DPM (Army)

Abstract

This paper presents the results and lessons learned from trial usage of the Software Engineering Institute's (SEI) Software Process Framework (SPF). The SPF was used to check consistency of the Cleanroom Software Engineering (CSE) process against the SEI Capability Maturity Model (CMM) for Software. The trial usage was done for a STARS (Software Technology for Adaptable, Reliable Systems) supported software development project, Improved Mortar Ballistic Computer (IMBC), at the US Army's Picatinny Arsenal Life Cycle Software Engineering Center (LCSEC). The main conclusions reached are:

- The SPF is a valuable tool for checking a software process for consistency against the recommendations made by the SEI CMM.
- The SPF should be viewed as a valuable process definition aid to support refining existing processes and for defining new ones, that both satisfy an organizations process requirements and satisfy CMM Key Process Area (KPA) process assurance criteria.
- Each SPF KPA description is made easier to use than the CMM equivalent description through its concise representation as an ETVX[1] based process definition and its concise summary of roles, training and measurements required to support the process.
- The SPF, and the CMM from which the SPF was derived, were designed to be software development process and life-cycle independent. Consequently, they do not provide complete coverage for all activities required to support an organization's software development life cycle.

[1] The CSE process definition is based upon a graphical ETVX [Arnold 92b] process notation. ETVX (Entry criteria, Tasks performed, Verification conditions, and eXit criteria) process notation is geared more toward activities performed, the validation of these activities, and the state data/documentation maintained.

Software Process Framework

The SPF was derived from the CMM for Software v1.1 [Paulk 93] in a format that pulls together the many references to process practice contained within the CMM. It should be recognized that the SEI CMM is an invaluable tool for assessing the maturity of organization and project processes, and for identifying aspects of these processes that meet compliance criteria set forth for each CMM KPA. Since the CMM was developed to assess the maturity of an organization's software development practices and to identify where weaknesses existed in an organization's processes, it should be recognized that the CMM is not a tool for defining a software development process. It is a tool that identifies required coverage areas for that process.

One of the common complaints concerning the CMM is the organization of the information contained within the document. References to software process practice for a given CMM KPA are not located in the same section but are dispersed throughout the document. This makes the job of reviewing a defined process against the recommendations made by the CMM particularly difficult for an organization trying to improve their CMM maturity rating or trying to define a CMM consistent process.

The SPF allows an organization to determine whether their software process is consistent with the recommendations made in the CMM in a much more organized fashion. It also permits the documentation of areas of inconsistency, allows for the evaluation of these areas of inconsistency as to whether they are really applicable in a given situation, and provides a possible basis for making informed decisions on process improvements.

The SPF comprises a set of templates derived from the CMM and maps all CMM KPA specific recommendations into ETVX-based process definition tables. The templates include the specific text from the CMM, the level/page/item reference for the text from the CMM, a check off box (to indicate consistency), and space for a reference into the process under review where the process reviewer indicates the extent of consistency. The SPF provides further clarity by providing sections for each KPA that have CMM specific recommendations for roles, entry criteria, inputs, activities, outputs, exit criteria, reviews/audits, measurements, tools, work products managed and controlled, documented procedures, and training. The SPF covers all KPAs of all CMM levels and the SEI has made this available to the general public as a handbook [Olson 94]. A example is provided in table 1 for the Activities section of the Peer Review (PR) KPA for CMM level 3 excerpted from the SPF.

✓	Activities	References
	Peer reviews are planned, and the plans are documented. (L3-97, A1)	
	Peer review are performed according to a documented procedure. (L3-97, A2)	
	Data on the conduct and results of the peer reviews are recorded. (L3-99, A3)	
	Measurements are made and used to determine the status of the peer review activities. (L3-99, M1)	
	The **software quality assurance group** reviews and/or audits the activities and work products for peer reviews and reports the results. (L3-100, V1)	

Table 1: Example of Activities for Peer Review KPA

Background

The LCSEC at Picatinny Arsenal is a representative DoD Software Support Activity that wants to apply a more formal approach to software support. The current state of software engineering at the LCSEC varies from project to project but the majority have not achieved the desired level of productivity and quality. A major goal of the LCSEC is to achieve a SEI CMM level 3 rating by adopting an evolutionary process improvement approach to software engineering.

The Picatinny Arsenal was involved in a STARS-sponsored process technology transfer demonstration that has shown very dramatic results [Sherer 94]. To date the Picatinny Arsenal has realized numerous benefits from the demonstration project, the re-engineering of the Mortar Ballistic Computer:

- increased software development productivity from a baseline of 121 LOC per person month to 531 LOC per person month,
- dramatic lowering of error rates in software development to a level that currently is 0.25 errors per KLOC,
- dramatic increase in moral and job satisfaction of the engineering staff
- successful transfer of STARS process technology that addresses levels 2, 3 and 5 KPAs into a CMM level 1 organization.

Based upon this successful demonstration, LCSEC management wanted to achieve a CMM level 3 by evolving the organization's existing process technology. Management decided that future re-engineering efforts would make use of the STARS-sponsored technologies. The problem was identifying just how well the STARS-sponsored technologies met CMM recommendations for a level 3 organization.

Trial Usage Pilot Goals

The SEI, as a collaborative member of the STARS program, was looking for a candidate trial use pilot for a new product, the Software Process Framework. The SEI was particularly interested in trial use of a well defined process above the CMM level 2 (Repeat Level) since there were few candidate processes above level 2. The Picatinny Arsenal project was using the Cleanroom Software Engineering (CSE) process, which had been defined from work performed earlier in collaboration between the SEI and STARS program. CSE is a well defined and experience tested process, developed at IBM over 15 years ago, became part of the SEI Process Asset Library (PAL) [Arnold 92a] and addresses the requirements of several level 2, 3 and 5 KPAs. The KPAs which this process addresses in substantial fashion are show in table 2 below:

Level 2 KPAs addressed	RM SPP SPTO SQA	Requirements Management Software Project Planning Software Project Tracking and Oversight Software Quality Assurance
Level 3 KPAs addressed	PR IC SPE ISM	Peer Review Intergroup Coordination Software Product Engineering Integrated Software Management
Level 5 KPAs addressed	DP	Defect Prevention

Table 2: Area's of Substantial CMM KPA Coverage by Cleanroom

For the purposes of the trial usage, the SEI provided the SPF for CMM levels 2 and 3, since levels 4 and 5 were not complete at the time the trial was setup. The objectives included:

- feedback to the SEI on the usage of the SPF against a CMM level 3 process
- production of a consistency check for the as defined CSE process against the CMM
- production of a document that described for the LCSEC at the Picatinny Arsenal, what CMM level 2 and 3 KPAs were addressed by CSE and KPAs that were not addressed.

This third objective will facilitate the planning of process activities required to enhance existing CSE process components that do not completely satisfy Level 2 and 3 KPA requirements, and those processes that need to be developed and interfaced with the CSE process, as it is currently being practiced at Picatinny. This work was not intended to be a substitute for a Picatinny software capability evaluation.

It should be noted that the CSE process does not address all activities of the systems development life cycle. Its coverage overlaps with the traditional systems engineering activities of software architecture development and software system specifications, through to the final build and certification of a software-intensive system. It also addresses management oversight, project monitoring and control. It was designed to support process-driven software development and many successful systems have been implemented through its use. In the next section we will present an expanded view of Table 2 to show the allocation of SPF/CMM KPAs and CSE process components to the IMBC process architecture, and to provide the reader a context in which to view the SEI Software Process Framework.

Software Process Framework and the Software Development Process

From our experiences on the IMBC Project at the US Army's Picatinny Arsenal, we have found it difficult to define a single process that addresses all of the relevant dimensions of a project. All software process definitions for projects require at least three major project processes which are networked and cooperatively performed. These three processes, shown on Figure 1, provide services to and support the work required by one another. Lower level processes are subsequently defined to support the mission of, and are encapsulated within, their parent process. Figure 1 illustrates the IMBC process architecture concept, which is composed of three major processes: 1) project management, 2) application engineering and 3) site/project services, where:

- The mission of the project management process is to plan technical work, review work status and progress and to control the software development project
- The mission of the application engineering process is to develop a software system that meets all stated requirements and quality objectives, within specified constraints
- The mission of the site/project services process is to provide the project management process and the application engineering process with services and support to help meet project objectives for the software product to be produced, and the objectives of the organization of which the project is a part.

This simple process architecture provides a framework for defining processes to support:

1. project management,

2. product development, and
3. product baseline control, quality assurance, and project process management.

We also used this process architecture as a tool, to depict where and how the Software Process Framework fits, with respect to process planning. To support our Software Process Framework pilot goals, we allocated key CSE processes and their respective SPF KPAs to the high-level IMBC process architecture components shown in Figure 1. A more detailed discussion of the IMBC Project process architecture can be found in [ETT 94].

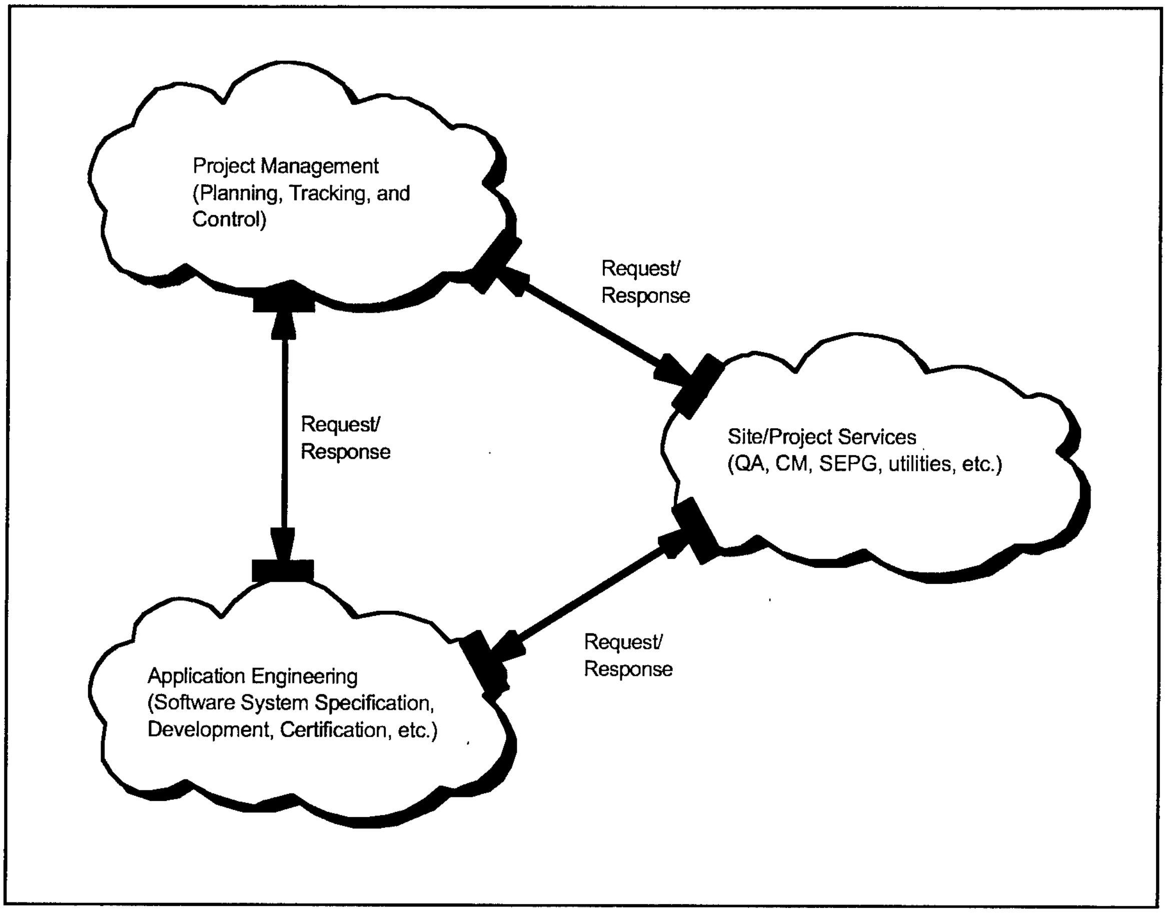


Figure 1: High-Level IMBC Process Architecture

Using the IMBC process architecture as an allocation tool enabled us to better understand the correlation between CSE process components and SPF KPAs. There was not always a match. It is important to recognize that the SPF and the CMM KPA descriptions from which they were derived, were intended to be process independent. The SPF provides guidance as to what your organization's and project processes should contain from a software process management/assurance perspective, and not from an organization's or project's process-driven software development perspective. Thus, it is perfectly reasonable that a software development process, such as the CSE process may contain processes for which there is no correlation to the SPF, or visa versa. The allocation of SPF KPAs to the high-level IMBC Cooperative Processes are shown in Table 3.

IMBC Process Component	Cleanroom Process ID	SPF KPAs
Project Management		Level 3 - ISM
Project Planning	E1, E2, E8	Level 2 - SPP
Project Tracking	E1, E2, E3, E7, E9	Level 2 - SPTO
Project Control	E2, E3, E8	Level 2 - SPTO Level 2 - SSM
Baseline Control		
Requirements	E4	Level 2 - RM
Software Architecture	E4, E15	Level 3 - SPE, IC, PR
Product/Software Releases	E4, E6, E15	Level 3 - PR
Site/Project Services		
Software Configuration Management	E14, E22	Level 2 - SCM
Baseline Maintenance (Products/Software Release)		Level 2 - SCM
Software Quality Assurance	Built In	Level 2 - SQA
SEPG Process Definition Support		Level 3 - OPD, OPF
Application Engineering		
S/W System Specification Development	E4, E8, E11, E12, E13, E14, E15, E20, E21	Level 5 - DP Level 3 - PR, IC Level 2 - SCM, SQA
S/W Release(i) Specification Development	E4, E8, E11, E12, E13, E14, E15, E20, E21	Level 5 - DP Level 3 - PR, IC Level 2 - SCM, SQA
S/W Release(i) Development	E5, E8, E11, E16, E18, E24	Level 3 - PR, IC Level 2 - SCM, SQA
S/W Release (i) Certification	E5, E8, E11, E6, E17, E19, E22, E23, E24	Level 5 - DP Level 3 - PR, IC Level 2 - SCM, SQA
S/W System Build and Certification	E22, E6, E8, E11, E23	Level 5 - DP Level 3 - IC Level 2 - SCM, SQA
S/W System Operational Test	E23, E8, E11	Level 3 - IC

Table 3: IMBC Process Architecture / SPF KPA Allocation

The allocation results shown in Table 3 illustrates the intersection between the SPF/CMM KPAs and key processes of the IMBC process architecture. The process definition strategy adopted for process definition work on STARS is to:

1. Define the work flow of activities for a project, to define how the project intends to perform software development (do business),
2. Define the project's process architecture, based on the allocation of those process components and
3. Map SPF/CMM KPAs to the appropriate components of the project's process architecture to ensure proper CMM KPA coverage is addressed by the project's process components.

To illustrate the mapping defined in point 3, E18 is the process named "Develop Increment i." Figure 2 illustrates the basic tasks required to support this process, and illustrates an interface to the "Peer Review Process" to support “black box validation." A software development process for an organization needs to be specified to illustrate how an organization and its projects intend to develop software products to facilitate process-driven software development. The SPF is needed to aid in the planning of those processes, to ensure CMM KPA requirements are addressed.

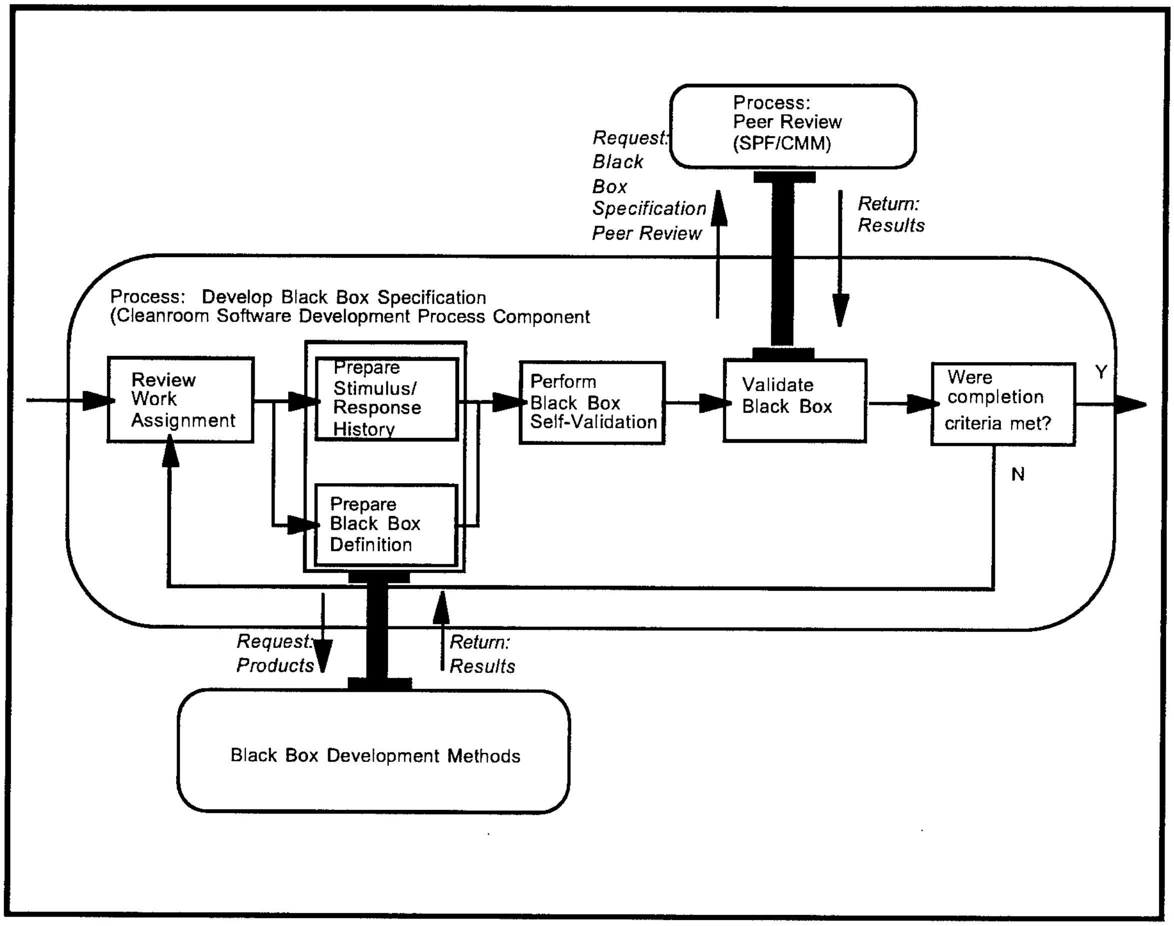

Process:
Peer Review
(SPF/CMM)
Request: Black Box Specification Peer Review
Return: Results
Process: Develop Black Box Specification
(Cleanroom Software Development Process Component
Review Work Assignment
Prepare Stimulus/ Response History
Prepare Black Box Definition
Perform Black Box Self-Validation
Validate Black Box
Were completion criteria met?
Y
N
Request: Products
Return: Results
Black Box Development Methods

Figure 2: The Black Box Specification Process and its Interface to the Peer Review Process.

It should be noted that defining processes which solely address CMM KPAs, would not be sufficient to enable process-driven development. The management of software development efforts and the product assessment and assurance aspects would be addressed, but the process for software development would not. KPAs that are not directly addressed by the CSE process are software configuration management, training, subcontractor management, organization process focus, and organization process definition. The omission of KPA coverage from the CSE process does not reduce its effectiveness as a process defined to support software systems development. Further, these KPA coverage areas can be added to the IMBC process architecture, and interfaced with other IMBC process components to provide support and services.

Now that we have defined our objectives for the SPF trial pilot project and provided a context in which the SPF can be viewed and successfully used, we will describe the results obtained from our pilot effort.

Results of the Trial Usage Pilot

The results of the trial usage were generally very positive. The format and layout of the SPF is a major improvement in usability of the information contained within the CMM. Users familiar with the CMM are aware of the difficulty of trying to reference all CMM statements concerning a specific aspect of an area of interest. The templates, organized by KPA and specific areas within a KPA, made it relatively easy to review a well organized, defined process. To check roles or entry criteria, for example, as defined by a given process, required that:

- one look up that specific template for a given KPA,
- run down the list of recommendations,
- determine how well documented the recommendation was in the defined process, and
- enter the reference for the defined process.

Additional notes could be taken at this point that would document areas for process improvement.

Quite frequently, the text reference in the SPF, was not a clear statement that was able to stand by itself without the supporting context from the CMM. This required the checking of the context from the CMM to be able to perform a proper evaluation. While this was somewhat inconvenient, it was not a major problem because the SPF templates included the reference for the requirement.

The SPF was a useful tool for identifying areas for improvement in the process description, missing elements, and a substantial number of improvements to the defined process. This despite the fact that the CMM has a decided management and quality assurance frame of reference rather than a software development reference. The process description, on the other hand, was geared towards software development. These improvements to the defined process include:

- descriptions of roles, the responsibilities required, including training,
- changes in terminology to more closely reflect standard usage,
- numerous instances of clarifications to vague requirements in the defined process,
- better identification of the activities/tasks with the role responsible, and
- numerous areas identified where it would be appropriate to add new process description for missing functionality (according to the CMM).

It should be pointed out that the CSE process description used for this review is considered to be a model of completeness and one of the best examples, in the general literature, of a well defined process. The fact that the SPF could improve such a well defined process to this extent speaks well for the usefulness of the SPF.

A requirement that became quite evident from the very beginning for the performance of this task was the decision to use as a basis for this analysis the version of CSE process that had been defined for the SEI Process Asset Library (PAL) [Arnold 92a]. This is the basis for the current process in use at the Picatinny Arsenal but this process has been enhanced and improved through usage by the software development teams. Improvements to the process have not been documented in a formal manner and thus the task of performing an analysis against this improved but undocumented process was impossible. The SPF requires the user to provide a reference into the documented process. If the improvement is not documented, it can not be considered to be repeatable because there are dependencies on the users that are not acceptable. For these cases, the evaluation of the process was marked as non-consistent. Little is included in the defined process concerning support activities required such as training and coaching activities that are used at the Picatinny Arsenal. These activities have been recognized as a very important ingredient of the success there [Sherer 94]. The defined process did not fit the actual process in use at the Picatinny Arsenal but any other interpretation opened a Pandora's box of intended process versus defined process. It was felt better to keep this box closed or the second guessing of intended functionality would be impossible to bound. Current plans include the introduction of a process definition tool to address the task of keeping the defined process updated.

Problem Areas

Problems were experienced with the mapping of SPF/CMM KPAs to the components of the CSE process. The mappings from the SPF/CMM KPAs to CSE process components were not one to one, and the SPF/CMM KPAs were organized at varying levels of abstraction. For example, the level 3 "Peer Review KPA" process capabilities are intended to support a low level development process, as opposed to "Integrated Software Management KPA" process capabilities which is intended to support all project management processes. This difference in KPA coverage and weight makes the mapping exercise difficult. Consequently some CSE process components provided better SPF/CMM KPA coverage than others. Where the CSE process addressed a different set of concerns than the SPF/CMM KPA, a conservative approach was taken to evaluate compliance. This approach required substantial compliance of the CSE process component with the SPF template, to assert the CSE process component as compliant.

The mapping of SPF/CMM KPAs to CSE process components helped in our compliance evaluation, but the apples and oranges nature of the SPF/CMM

KPAs and the process coverage they address made compliance evaluation a challenge in some cases. This experience strengthened our belief in representing process components as objects which provide and receive products and services from each other. The excellent organization of the CSE process components as black boxes enables the definition of process components, which more closely addressed SPF/CMM KPA coverage requirements, that would easily interface with existing CSE processes.

In some cases the CSE process components met the spirit of the SPF/CMM KPAs, but not the letter, as defined in the SPF/CMM KPAs. An example of this is the fact that the CMM is skewed towards defect removal not defect prevention. The CSE process takes a different approach from traditional software development by emphasizing defect prevention and a method of testing that is based upon statistical certification of the reliability of the product. There is a lack of testing as defined by the CMM.

CSE uses a process called Certification that uses a Usage Profile, how the software is used in actual practice, to accomplish "testing" in the traditional sense of the CMM. Statistical analysis of the Usage Profile, performed by a tool, is used to generate test cases. The number of test cases generated is dependent on the user entered required quality, i.e. 99% reliability of error free code and 99% confidence interval. The resulting product, if all test cases run error free, has a statistical certified reliability. Managers have the capability, based upon time and budget constraints, to make very informed decisions about the quality of the delivered product. This methodology has the added value of removing from the end product those errors that the end user is most likely to see in actual usage and so the perceived quality of the product is also higher. In cases such as these, the differences were documented with justifications provided for the difference in approach that in the end had the same objective, error free software at delivery.

The SPF had a lot of redundancy in the template descriptions for a given KPA. One would find the same requirement listed under roles, activities, and exit criteria for example. This tends to be annoying but does provide for more detail and assures that nothing is missed. The rationale for the redundancy, provided by the authors of the SPF, was that the templates were meant to be a stand alone document, allowing one to take various perspectives on the defined process.

Software Process Framework Support for Cleanroom Process Re-engineering

The amount of effort required to perform this analysis for all level 2 and 3 KPAs was fourteen (14) person days. This included level 3 KPAs Peer Review, Intergroup Coordination, Software Product Engineering, and Integrated Software Management. Level 2 KPAs included Requirements Management, Software Project Planning, Software Project Tracking and Oversight, and Software Quality Assurance. These were the KPAs for which the defined process had a "substantial" impact. The process model description is approximately 500 pages in length and this was deemed a rather efficient review of the amount of material included.

In order to judge the impact of this analysis on the defined process and to get an indication of the difficulty of the analysis, detailed summary data is presented in table 4 for the Peer Review KPA and table 5 for the Intergroup Cooperation KPA. This data is representative of the work performed where the SPF identified areas for improvement in existing process components, areas difficult to map into existing process components, and the complexity of interpretation required for each KPA subsection.

The "Difficulty of Mapping" column refers to the degree of similarity between the defined process and a given KPA. If all required data for a KPA was found within a given CSE sub-process, there are 25 defined sub-processes within the CSE process, the mapping was considered easy. If the data was spread across numerous CSE sub-processes then the mapping was considered to be much more difficult.

The "Complexity of Interpretation" refers to the difficulty in interpreting the defined CSE process against the CMM KPA recommendations. If the defined process was worded and referenced very closely to the CMM KPAs it was considered to be easy. If the defined process used a different method to solve the spirit of the CMM KPA or had terminology differences which made the interpretation more difficult, it was considered to be hard.

KPA Subsection	Total Number of Items in SPF KPA (counts)	Identified Areas of Improvement in Defined Process (counts)	Identified Areas of Improvement if Training Satisfied (counts)	Difficulty of Mapping 1(easy) to 5(hard)	Complexity of Interpretation Required 1(easy) to 5(hard)
Roles	13	7	2	1	2
Entry Criteria	10	4	2	1	1
Inputs	3	0	0	1	1
Activities	5	1	1	1	1
Outputs	15	3	3	1	2
Exit Criteria	27	10	10	1	1
Reviews & Audits	6	6	4	1	1
Work Products Managed and Controlled	Not Applicable				
Measurement	2	1	1	1	1
Documented Procedures	1	0	0	1	1
Training	2	2	0	1	1
Tools	Not Applicable				
Totals	84	34	23		

Table 4: Software Process Framework - Peer Review KPA

The numbers for "Identified Areas of Improvement" on first look seem to indicate that large numbers of problems were found in the review of this KPA. This is not necessarily the case however since the amount of redundancy in requirements produces multiple entries in this column for one requirement. The training recommendation appears under Roles, Entry Criteria, Reviews & Audits as well as Training. Therefore, not being consistent with the CMM causes multiple "misses" in the SPF. The data in the "Identified Areas of Improvement if Training Satisfied" column represents the effect of compliance with the requirement on training for peer review leader and reviewers. The effect of compliance with the one training requirement would reduce the number of Identified Areas of Improvement from 34 to 23. There are additional cases within this same KPA that would have a similar, although some what less dramatic impact.

The "Difficulty of Mapping" and "Complexity of Interpretation" column for table 4 reflect the very close relationship between the defined CSE Peer Review process and the requirements of the CMM. Table 5 shows that there was a much higher level of difficulty in the mapping and interpretation. This was due to some significant problems with deciding the boundaries between the Intergroup Coordination and the Software Product Engineering KPAs as defined in the CSE process. There were additional problems due to the fact that this KPA spanned so many CSE sub-processes.

KPA Subsection	Total Number of Items in SPF KPA (counts)	Identified Areas of Improvement in Defined Process (counts)	Difficulty of Mapping 1(easy) to 5(hard)	Complexity of Interpretation Required 1(easy) to 5(hard)
Roles	39	8	5	4
Entry Criteria	7	5	3	2
Inputs	18	5	5	3
Activities	21	5	5	2
Outputs	28	6	5	2
Exit Criteria	73	12	5	2
Reviews & Audits	16	3	4	2
Work Products Managed and Controlled	Not Applicable			
Measurement	1	1	1	1
Documented Procedures	2	0	1	1
Training	3	3	1	1
Tools	1	1	1	1
Totals	209	49		

Table 5: Software Process Framework - Intergroup Cooperation KPA

The review of a defined process against the SPF requires a very knowledgeable reviewer. The better a defined process is documented, the easier the job will be. In any case these activities are intense in nature and require a lot of work, even with the SPF. The SPF did, however, make the job much easier than trying to deal with the CMM. The results of this analysis will be used to perform three functions:

- improve the CSE process definition,
- provide a map for the Picatinny Arsenal of areas, not covered by CSE, that will need to be addressed in their evolution towards becoming a level 3 organization and
- prioritize which process areas should be addressed first.

A word of caution is in order for the potential user of the SPF. The SPF is not intended to serve as a substitute for software capability evaluation. The SPF is primarily useful for:

- the analysis of defined software process to check consistency with the CMM
- designing of software process so they are consistent with the CMM, i.e. process improvement efforts
- defining of organizational roles, responsibilities, and scope
- providing recommendations on requirements for particular CMM levels.

It is important to remember that the CMM has its greatest strength when viewed from the management and quality control perspectives and any processes designed from this perspective will be weak from the perspective of software engineering concerns. This is not to minimize the importance of the CMM, but it is important to realize that there are important areas that are not currently addressed by the CMM.

References

[Arnold 92a] Arnold, Paul G., *Cleanroom Engineering Process*, Software Engineering Institute Process Asset Library, v2.0, Oct. 1992

[Arnold 92b] Arnold, Paul G., *Reader's Guide to SPMS Diagrams*, Software Engineering Institute Process Asset Library, v2.0, Oct. 1992

[Ett 94] Ett, William H., *SCAI Process Definition Training Package*, v1.0, Software Process Architecture Module, Feb. 94

[Olson 94] Olson, Timothy G., Neal R. Reizer, James W. Over, *A Software Process Framework for the SEI Capability Maturity Model*, Handbook CMU/SEI-94-HB-01, Sept. 1994

[Paulk 93] Paulk, Mark C., Bill Curtis, Mary Beth Chrissis, Charles V. Weber, *Capability Maturity Model for Software*, v1.1, 1993

[Sherer 94] Sherer, S. Wayne, Paul G. Arnold, Ara Kouchakdjian, *Successful Process Improvement Effort Using Cleanroom Software Engineering*, Proceedings of the 6th Software Technology Conference, May 1994

The Software Process Framework is available through the following sources:

Research Access, Inc., 800 Vinial Street, Pittsburgh, PA. 15212
Phone: (800) 685-6510 FAX: (412) 321-2994

National Technical Information Service (NTIS), U.S. Department of Commerce,
Springfield, VA. 22161 Phone: (703) 487-4600

Defense Technical Information Center (DTIC), Attn. FDRA, Cameron Station,
Alexandria, VA. 22304-6145 Phone: (703) 274-7633

Software Process Framework, Tool to Determine Consistency With the CMM

Paul G. Arnold
Loral Federal Systems
Internet: pga@sei.cmu.edu
Phone: (301) 240-7464

Outline for Presentation

- What is the Software Process Framework?
- Trial Usage Pilot Objectives
- Process Architecture
- Results of the Trial Usage Pilot
- Process Re-engineering
- Conclusion

Software Process Framework

- Derived from the CMM for Software, V1.1
- Brings together recommendations from CMM into a logically organized structure
- Set of Templates organized into ETVX based process definition tables
  - text reference from CMM
  - check off box to indicate consistency
  - reference into process under review

Software Process Framework

- SPF arranged by maturity level and key process areas
- Key Process Areas
  - roles entry criteria inputs activities
  - outputs exit criteria reviews/audits
  - measurements tools work products
  - documented procedures training

Example of Activity Table

✓	Activities	References
	Peer reviews are planned, and the plans are documented. (L3-97, A1)	
	Peer review are performed according to a documented procedure. (L3-97, A2)	
	Data on the conduct and results of the peer reviews are recorded. (L3-99, A3)	
	Measurements are made and used to determine the status of the peer review activities. (L3-99, M1)	
	The **software quality assurance group** reviews and/or audits the activities and work products for peer reviews and reports the results. (L3-100, V1)	

Source: SPF pg. L3-Process-184

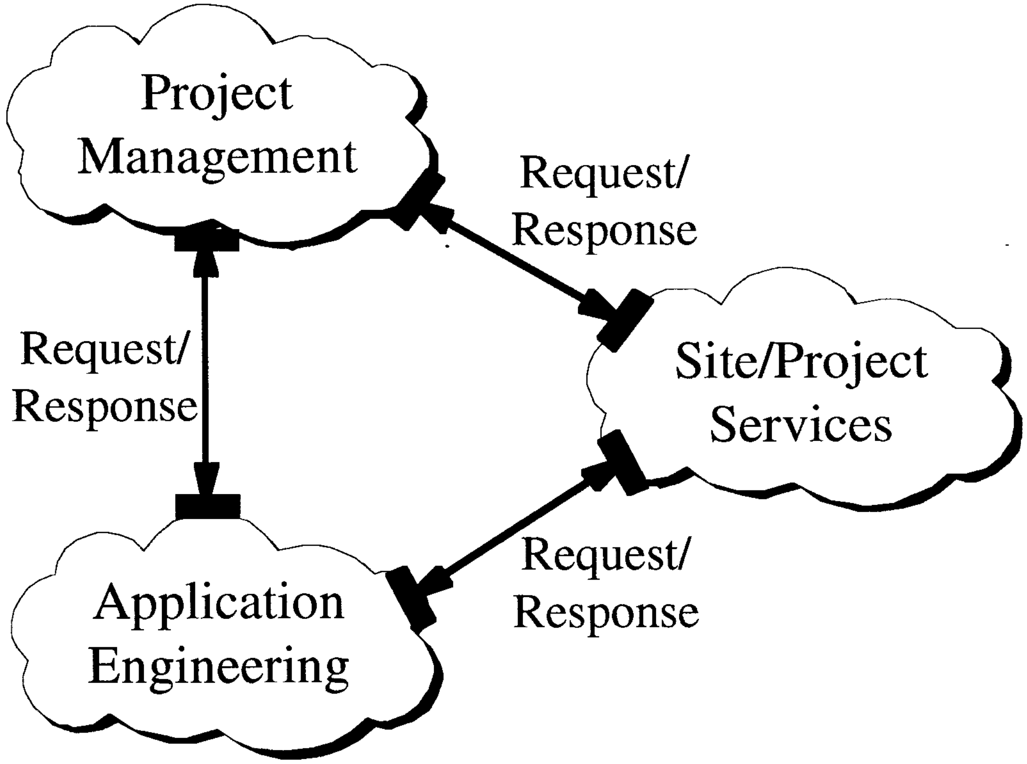
Trial Usage Pilot Objectives

- Feedback to the SEI for a CMM level 3 process
- Production of a consistency check against the CMM for Cleanroom Software Engineering Process
- Documentation of CMM level 2 and 3 KPAs addressed and not addressed

Areas of Substantial Coverage by Cleanroom Process

Level 2 KPAs addressed	RM SPP SPTO SQA	Requirements Management Software Project Planning Software Project Tracking and Oversight Software Quality Assurance
Level 3 KPAs addressed	PR IC SPE ISM	Peer Review Intergroup Coordination Software Product Engineering Integrated Software Management
Level 5 KPAs addressed	DP	Defect Prevention

Process Architecture



Project Management

Request/ Response

Site/Project Services

Request/ Response

Application Engineering

Request/ Response

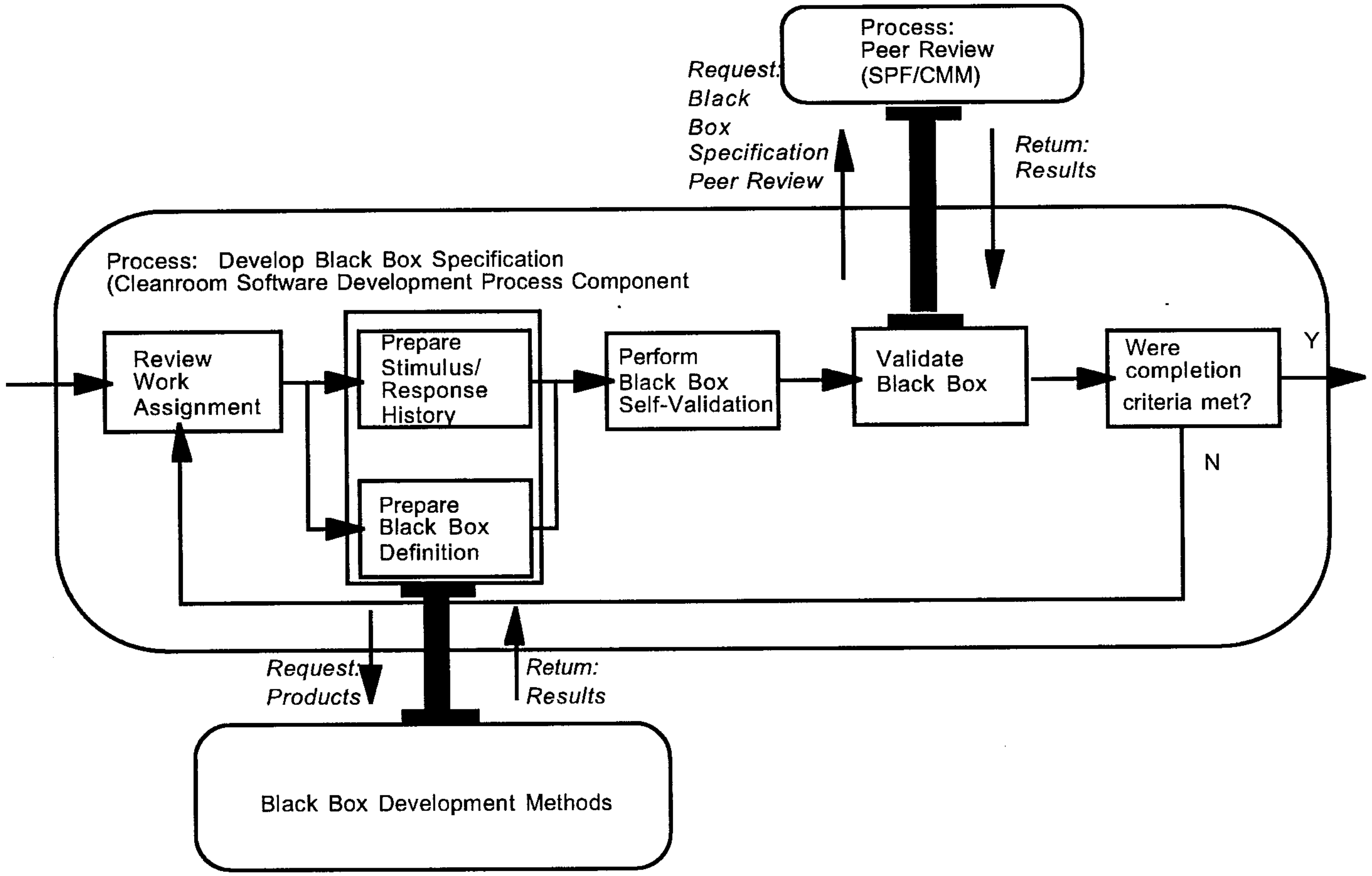
Process Architecture / SPF KPA Allocation

Application Engineering	Cleanroom Process ID	SPF/CMM KPAs
S/W System Specification Development	E4, E8, E11, E12, E13, E14, E15, E20, E21	Level 5 - DP Level 3 - PR, IC Level 2 - SCM, SQA
S/W Release(i) Specification Development	E4, E8, E11, E12, E13, E14, E15, E20, E21	Level 5 - DP Level 3 - PR, IC Level 2 - SCM, SQA
S/W Release(i) Development	E5, E8, E11, E16, E18, E24	Level 3 - PR, IC Level 2 - SCM, SQA
S/W Release (i) Certification	E5, E8, E11, E6, E17, E19, E22, E23, E24	Level 5 - DP Level 3 - PR, IC Level 2 - SCM, SQA

Process Definition Strategy

- Define the work flow activities for a project
  - how the project will do business
- Define the project’s process architecture
  - based on allocation of process components
- Map the SPF/CMM KPAs to the project’s process architecture
  - to ensure proper CMM KPA coverage

Example Mapping



Positive Results

- SPF format and layout a major improvement in usability over the CMM
- SPF templates, organized by KPA and specific areas within KPAs
- Relatively easy to review a WELL DEFINED and ORGANIZED process

Positive Results - 2

- Example Review Process
  - look up specific template for a KPA
  - run down the list of recommendations
  - determine how well documented the recommendation was in the defined process
  - enter the reference for the defined process
  - take notes on clarifications required, etc.

Positive Results - 3

- Frequently CMM text reference in SPF did not contain enough context
  - required cross check with CMM
  - SPF contains level/page/item reference
- SPF useful in determining areas for improvement in the process description

Positive Results - 4

- Improvements to the process included
  - description of roles, the responsibilities required, including training
  - changes in terminology
  - clarifications of vague requirements
  - better identification of activities/tasks
  - missing functionality (according to CMM)

Problem Areas

- Mapping of SPF/CMM KPAs to the defined process
  - Peer Review KPA
    - close to one to one mapping
  - Integrated Software Management KPA
    - all project management processes
  - consequent wide variation in degree of coverage by defined process

Problem Areas - 2

- CMM skewed toward management and quality assurance objectives
  - not designed for software engineering concerns
- Defined process met spirit of CMM but not the letter as defined in the CMM
  - debugging Vs. defect prevention
  - testing Vs. certification
- Lot of redundancy in template descriptions

Effort Required for Analysis

- Analysis performed against KPAs
  - Level 3: PR, IC, SPE, ISM
  - Level 2: RM, SPP, SPT&O, SQA
- Required Effort was fourteen (14) days
- Defined Process was 500 pages
  - very well defined and organized process
- Effort considered very efficient

Process Re-engineering

- Identified Areas of Improvement
  - not consistent with SPF KPA
- Difficulty of Mapping
  - degree of spread across multiple sub-processes
- Complexity of Interpretation
  - terminology problems
  - different method for achieving same end result

Process Re-engineering Peer Review KPA

KPA Subsection	Total Number of Items in SPF KPA (counts)	Identified Areas of Improvement in Defined Process (counts)	Identified Areas of Improvement if Training Satisfied (counts)	Difficulty of Mapping 1(easy) to 5(hard)
Roles	13	7	2	1
Entry Criteria	10	4	2	1
Inputs	3	0	0	1
Activities	5	1	1	1
Outputs	15	3	3	1
Exit Criteria	27	10	10	1
Reviews & Audits	6	6	4	1

Process Re-engineering Intergroup Cooperation KPA

KPA Subsection	Total Number of Items in SPF KPA (counts)	Identified Areas of Improvement in Defined Process (counts)	Difficulty of Mapping 1(easy) to 5(hard)	Complexity of Interpretation Required 1(easy) to 5(hard)
Roles	39	8	5	4
Entry Criteria	7	5	3	2
Inputs	18	5	5	3
Activities	21	5	5	2
Outputs	28	6	5	2
Exit Criteria	73	12	5	2
Reviews & Audits	16	3	4	2

Process Re-engineering

- Results of analysis used to
  - improve process definition
  - provide map of areas not covered by defined process needed for CMM level 3
  - prioritize which process areas to address first

Conclusions

- The SPF is primarily useful for:
  - analysis of defined process to check consistency with the CMM
  - designing a process to be consistent with the CMM
  - defining organizational roles, responsibilities and scope
  - providing recommendations on requirements for particular CMM levels

Conclusions - 2

- SPF is much easier to use than the CMM
- SPF/CMM has its greatest strength for
  - management control
  - quality assurance
- SPF/CMM does not address software engineering concerns