Software Engineering Institute

Progress Toward an Organic Software Architecture Capability in the U.S. Army

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Abstract

The goal of the United States Army Strategic Software Improvement Program is to dramatically improve the acquisition of software-intensive systems. One of the initiatives undertaken by the program is to begin building a level of technical expertise in modern software architecture practices within the Army acquisition community.

This report describes the Software Architecture Initiative of the Army Strategic Software Improvement Program. Results to date are encouraging and serve as a guide for other acquisition organizations seeking to strengthen their technical competencies.

1 Introduction

The modern military increasingly relies on sophisticated and ever more complex weapons, information, and communications systems to perform its tasks. Adding to that complexity is the desire to create a network-centric force capable of employing those systems in new and emergent ways to achieve unparalleled and unprecedented battlefield dominance. The backbone of these systems and capabilities is software. Software drives the functionality and performance of these systems as well as the intricate networks that tie them together.

Since late 2002, the Carnegie Mellon® Software Engineering Institute (SEI) has been working with the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT)) in a strategic partnership. The objective: Improve the Army's techniques for acquiring systems with high software content, called software-intensive systems,[1] or SIS. Known as the Army Strategic Software Improvement Program, or ASSIP, the program is devising strategies and initiatives that will ultimately enhance the U.S. Army's ability to be a "smart buyer" of software-intensive systems.

One ASSIP initiative focuses on software architecture. Sound software architecture practices are a strong success factor in SIS programs. However, initial investigations into Army SIS acquisition indicated that while software architecture practices were deemed important, methods and skills to carry out those practices were perceived to be inadequate. In response, the ASSIP formulated an initiative to build an organic software architecture capability within the Army acquisition community.

This technical report describes the work done to lay the foundation for an organic Army software architecture capability. That includes training Army professionals in software architecture practices and conducting software architecture evaluations, both as part of the ASSIP Software Architecture Initiative (SAI) and separately. This report provides an accounting of the results and lessons learned from the initiative and related work, and enables the launch of similar approaches in the broader acquisition community. The results of architecture evaluations undertaken by selected Army acquisition programs will be the subject of other reports.

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1 According to the Defense Acquisition University (DAU), a software-intensive system is one in which software represents the largest segment in one or more of the following criteria: system development cost, system development risk, system functionality, or development time [DAU 2005].

2 The ASSIP

Before examining the details of the SAI, a brief background on the ASSIP will provide the reader with context. The ASSIP is a multiyear effort targeted at dramatically improving the way in which the Army acquires software-intensive systems. To achieve this goal, the ASSIP works directly with the Army's Program Executive Officers (PEOs) and the program management offices (PMOs) that they oversee. Although sponsored by the ASA(ALT), the ASSIP strives to include representation from Army organizations that are not necessarily acquisition organizations, per se, but influence Army acquisitions. This broader sense of an *Army acquisition community* includes

- the Army Software Engineering Centers (SECs) that provide software support for fielded systems (and, in some cases, new development)
- the Army Test and Evaluation Command (ATEC), which is responsible for testing Army materiel solutions
- the Army Training and Doctrine Command (TRADOC), which defines the capabilities to be addressed by materiel solutions and also provides an interface to the end users

The ASSIP also maintains contact with other organizations such as the Defense Acquisition University (DAU) and the acquisition functions of the other services to stay abreast of developments and issues that affect military acquisition in general.

Organizationally, there are two main bodies involved in the ASSIP: the Senior Steering Group (SSG) and the ASSIP Action Group (AAG). The SSG, composed of the Army's PEOs, the military deputy (MILDEP) to the ASA(ALT), and the director of the SEI, provides overall guidance to the effort. The AAG, which consists of representatives from each of the PEOs and from the SECs, ATEC, TRADOC, as well as SEI technical staff members, develops and implements improvement strategies. The ASSIP is a collaborative partnership; the SSG and AAG are co-chaired by the Army and the SEI. The SEI's role includes offering expert guidance on software acquisition and process issues, providing secretariat services to the SSG and AAG, and acting as a catalyst for change by serving as a transition agent to assist DoD organizations in applying modern software engineering practices. As depicted in Figure 1, the ASSIP is predicated on the idea that better acquisition practices will lead to better systems and overall results.

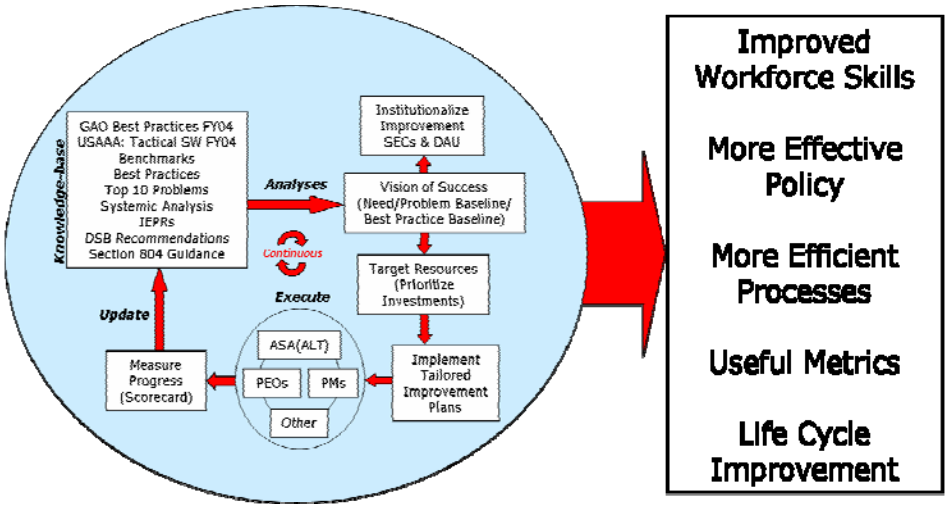

Figure 1: Continuous Improvement Yields a More Capable Acquisition Function

Early steps taken by the ASSIP included efforts to baseline the current state of Army acquisition in order to reason about what sorts of changes might be needed. Determining the baseline involved a three-phased approach:

1. Conducting a survey of Army acquisition professionals to get a lay of the land. As a first step toward understanding the current state of Army acquisition, the survey sought to provide preliminary insight into the major acquisition-related problem areas. Although not conclusive, the responses were invaluable in setting expectations about the range of potential problems.
2. Conducting a series of structured interviews (referred to as benchmarking for improvement, or BFI) with personnel from selected Army program offices to discover the effectiveness of the business practices and processes used within PMOs. Although interviews were structured around version 1.0 of the Capability Maturity Model Integration Acquisition Module (CMMI®-AM) [Bernard 2004], the BFI engagements elicited the processes employed by programs, using a model as a guideline, instead of rating program office processes against a model. BFI results were aggregated in a non-attributable manner to form a picture of Army acquisition from the program office perspective.
3. Conducting a series of in-person interviews with the Army's PEOs to get their unique perspectives on the state of Army acquisition. Each of the PEOs represented a wealth of acquisition experience. The interview questions, which were the same for each PEO, were formulated to glean the insights from that experience. Specifically, the interviews sought out the PEOs' overall opinions about Army acquisition, the activities in each PEO's office, and the ways in which the ASSIP could help improve acquisition of software-intensive systems. As with the BFIs, interview results were aggregated in a non-attributable manner.

Results of the inquiries are documented in [Kasunic 2004], [Keeler 2005], and [Blanchette 2005], respectively.

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These data-gathering approaches yielded information for structuring the ASSIP plan of attack. Each fiscal year (FY), the ASSIP produces a Strategic Software Improvement Master Plan (SSIMP) that delineates the tasks to be performed in that year. The tasks are aligned to *initiatives* that are based on the results of the initial baselining of Army acquisition as well as subsequent findings. One of those, the Software Architecture Initiative, is the subject of this report.

3 Motivation for Army Software Architecture Practices

The importance of software architecture practices to successful software-intensive programs is becoming increasingly well known. The Data and Analysis Center for Software (DACS)[2] lists an "architecture first approach" among its software acquisition *Gold Practices* [DACS 2004]. This appreciation of the value of software architecture practices is not a recent epiphany; a Defense Science Board (DSB) report from as far back as 1994 called out the potential for software architecture and product line techniques to reduce cost and cycle times [DSB 1994]. Additionally, a November 2000 report from the DSB highlighted software architecture as "a central theme for software reuse, product lines, and greater exploitation of commercial technology and practices" [DSB 2000]. In 2001, a U.S. Army lessons-learned workshop focusing on software upgrade programs concluded, in part, that architecture is "a key technical focus for the system," noting particularly the criticality of the architecture in determining the future ability to upgrade the system [Anderson 2001].

Considering the importance of software architecture practices to successful SIS acquisition, one might have expected that such practices were prevalent in Army (and other services') acquisition programs. Such appears not to be the case. In 2002, the Department of Defense (DoD) Tri-Service Assessment Initiative (TAI) reported that poor software architecture practices was one of the systemic causal factors of software-intensive systems issues, based on assessments of 21 DoD programs [McGarry 2002]. This finding suggests that simply engaging in a task called "software architecture" is insufficient to leverage the benefits of software architecture. It suggests that both acquirer and supplier should also engage in an evaluation of the architecture's quality and robustness to ensure that it is living up to its potential. Indeed, some larger defense contractors routinely use some form of architecture evaluation on many of their programs [Bass 2006].

Recently, the SEI conducted an analysis of 18 software architecture evaluations performed by the institute between 2000 and 2005, including 12 for DoD programs. The evaluations were conducted using the SEI Architecture Tradeoff Analysis Method® (ATAM®).[3] The analysis yielded some interesting results. For instance, more than half of the evaluations uncovered significant program risks related to an organization's failure to grasp the magnitude of the software architecture effort, as manifested by lack of training, lack of tools, poor planning, and other problems [Bass 2006]. This observation supports the findings of earlier reports: organizations pay insufficient attention to software architecture practices. Further, nearly two-thirds of all risks discovered

[2] DACS is a Department of Defense-sponsored Information Analysis Center managed by the Defense Technical Information Center (DTIC).

[3] Appendix B provides an overview of the ATAM. For a complete description, see [Clements 2002].

® Architecture Tradeoff Analysis Method is registered in the U.S. Patent and Trademark Office by Carnegie Mellon University.

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were risks of *omission* (for example, technical investigations not performed or architectural decisions either not made or not captured) [Bass 2006]. This observation suggests that architecture evaluators must be experienced enough to analyze a software architecture in detail, probing beyond the information that is typically presented.

An analysis of the findings from the ASSIP data-gathering efforts mentioned earlier pointed to software architecture as a problem area, consistent with the studies noted above. For instance, the survey of acquisition professionals revealed a general impression that prime contractors' software architecture abilities were, at best, about average [Kasunic 2004], suggesting a need for rigorous evaluation of software architectures to reduce program risk. Yet, according to the BFIs and the PEO interviews, staff skills within PMOs were not adequate to evaluate software architectures [Blanchette 2005], [Keeler 2005]. Thus, software architecture is an acknowledged good practice in SIS programs, yet it is one that is rarely executed effectively or evaluated rigorously.

Such a situation is a case of acquirer/supplier skill mismatch. As depicted in Figure 2, instances of low acquirer capability coupled with average supplier capability often lead to unpredictable results and even to program failure. Specifically, in the case of software architecture, limited expertise on the part of the Army can result in under-representation of stakeholder needs or inadequate reviews of suppliers' architectural work.

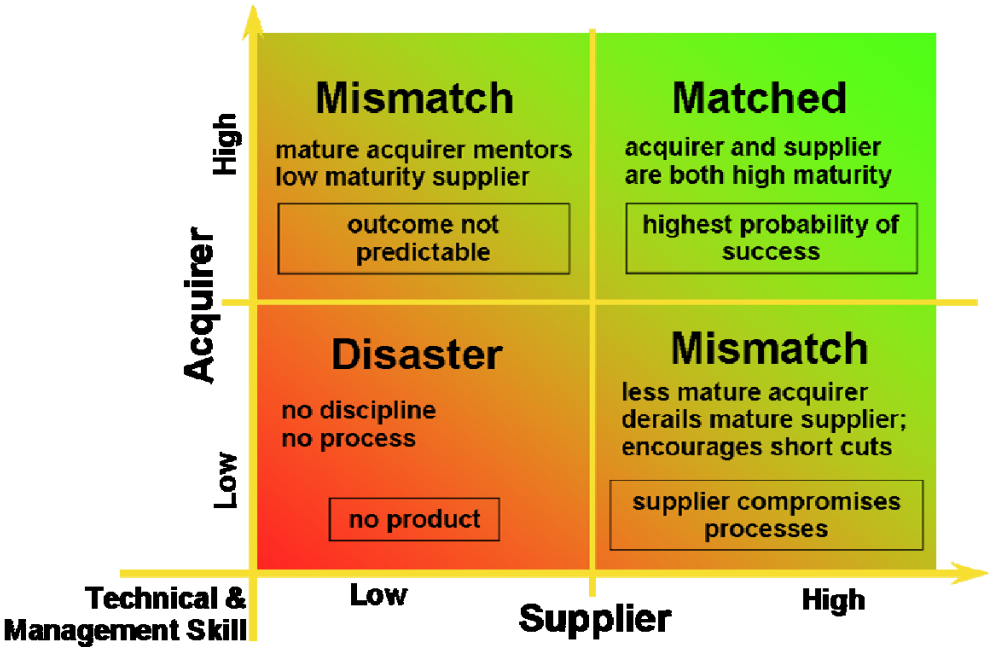

Figure 2: The Acquirer/Supplier Mismatch

Since the software architecture underpins the entirety of a software-intensive system, errors, omissions, or inflexibility in the architecture can lead to problems that are difficult and costly to fix as the system evolves, if they can be fixed at all.

In addition to the compelling evidence that software architecture is a key enabler of program success, the Army also had a directly relevant example. At the request of the Army, the SEI undertook a year-long study of the Force XXI Battle Command Brigade and Below (FBCB2) program in 2001. As the Army's first large-scale deployment of digitized capability, FBCB2 is crucial to plans for a networked fighting force. What the study team found was that FBCB2 software was on an inappropriate architectural path to support current or longer term operational use [Bergey 2005].

The Honorable Claude Bolton, ASA(ALT), grasped the significance of the various software architecture studies, particularly the findings of the FBCB2 study, for all Army acquisition programs involving software. Through his AAG representative Dr. James Linnehan, Bolton pushed the SEI to develop a proposal for an ASSIP initiative that would help to improve the use of sound software architecture practices in Army programs.

The proposal generated much discussion when it was briefed to the AAG, both because of its technical nature and because it was the first initiative to be proposed for ASSIP. Representatives discussed their own experiences with software architecture issues and debated the potential efficacy of the proposal. In the end, the AAG determined that an ASSIP initiative dealing with software architecture would be appropriate. The initiative would focus on improving PMO awareness and staff skills in software architecture.

The remainder of this report discusses the ASSIP software architecture initiative. Section 4 reviews the SAI and its implementation. Section 5 reviews the SAI results to date, including the lessons learned. Lastly, Section 6 discusses ongoing work.

4 The ASSIP Software Architecture Initiative

Beginning in FY04, the ASSIP started building an organic software architecture capability within the Army acquisition community. The purpose of the initiative, as stated in the SSIMP, was to train a cadre of Army technical professionals in the techniques of software architecture evaluation to better support the acquisition of SIS. Additionally, the initiative sought to introduce architecture evaluation in Army policy and infrastructure by piloting architecture evaluation techniques on three selected programs[4].

ASSIP is working to ingrain both the knowledge and practice of software architecture techniques into the culture of Army acquisition. Each successive SSIMP has defined new tasks within the software architecture initiative that build on the accomplishments of the previous year. In FY05, the ASSIP sponsored additional courses in the software architecture curriculum and three additional architecture evaluations[5]. Further, to help ASSIP architecture students apply their new skills, ASSIP began recruiting Army personnel who had received architecture training through the SAI and were SEI-authorized ATAM evaluators to participate on the evaluation teams. The FY06 SSIMP software architecture initiative included another three architecture evaluations that included Army personnel and an advanced series of courses from the SEI software product line curriculum.[6]

The following sections describe the software architecture training and software architecture evaluations in more detail.

4.1 SOFTWARE ARCHITECTURE TRAINING

The first step in the SAI was to train qualified Army technical professionals. The SEI established a special offering of its publicly available software architecture curriculum and delivered it at the Army SECs. The curriculum consists of six courses, as depicted in Figure 3.

[4] U.S. Army: Fiscal Year 2004 Strategic Software Improvement Master Plan. September 2003.

[5] U.S. Army: Fiscal Year 2005 Strategic Software Improvement Master Plan. October 2004.

[6] U.S. Army. Fiscal Year 2006 Strategic Software Improvement Master Plan. October 2005.

Requirements	Software Architecture Professional	ATAM® Evaluator	ATAM® Lead Evaluator
	Three Certificate Programs		
Software Architecture: Principles and Practice	✓	✓	✓
Documenting Software Architectures	✓		✓
Software Architecture Design and Analysis	✓		✓
Software Product Lines	✓		
ATAM ® Evaluator Training		✓	✓
ATAM ® Leader Training			✓
ATAM ® Observation			✓

Architecture Tradeoff Analysis Method ® (ATAM ®

Figure 3: The SEI Software Architecture Curriculum

Additional curriculum information, including course descriptions, may be found at http://www.sei.cmu.edu/activities/architecture/certificate_program.html.

The ASSIP offering of the curriculum was conducted with the full rigor of the publicly offered version. The SEI enforced the normal prerequisites for each course. Course content and material was identical to that in the SEI's regular public offerings, and the same qualified instructors who teach the public sessions taught the courses. Students in ASSIP-sponsored training earned certificates as depicted in Figure 3 for successful completion of course sequences.

The ASSIP paid for the courses, which were delivered at the various SECs. Students' home organizations paid for personnel time and any temporary duty (TDY) expenses (such as travel costs) associated with attendance. Holding the courses at the SECs minimized TDY expenses for a portion of each class since each software center is in close proximity to several PMOs and PEOs.

In each of FY04 and FY05, 30 slots were available to personnel involved in Army acquisition or acquisition support roles (due to the nature of the training, only 15 slots were available in each year for the more advanced ATAM evaluator and leader training courses). The ASSIP equitably allocated slots among the software centers, PEOs, and PMOs. Since the SECs are positioned to provide broad-based evaluation support, ASSIP made the limited slots for ATAM Evaluator and Leader courses available to them first; PEOs and PMOs were able to take advantage of the few slots not filled by SEC personnel.

The value of the courses has been recognized. In late 2005, the SEC at the Communications-Electronics Lifecycle Management Command (C-E LCMC) at Fort Monmouth asked the SEI to provide an offering of the software architecture curriculum especially for the Fort Monmouth community.

4.2 SOFTWARE ARCHITECTURE EVALUATIONS

Beginning in FY04, the AAG decided to sponsor a series of architecture evaluations using the SEI method known as ATAM. The goals of the evaluations were
(a) to begin institutionalizing software architecture practices by showing their value in real Army acquisition programs and (b) to provide opportunities for ASSIP-trained Army personnel to gain experience in applying the concepts of the architecture training.

A total of two ATAM evaluations and one SEI Quality Attribute Workshop[SM] (QAW[SM]) method[7] were conducted in FY04. ASSIP intended these initial pilot sessions to demonstrate the usefulness of the methods to the Army in general while providing valuable technical feedback to each of the participating programs. The FY04 evaluations were staffed entirely by skilled evaluators from the SEI. In FY05 and FY06, the ATAM and QAW evaluations were led and staffed by qualified SEI personnel. In addition, one to two Army personnel were included on each ATAM evaluation team; other Army personnel participated as observers.

Responsibility for nominating candidate programs fell to the AAG. After the success of the initial pilots in FY04, the AAG representatives nominated several programs as candidates for the ATAM evaluations and QAWs. However, the SEI found that many nominated programs were not yet ready for an evaluation, causing frustration both for the programs and for the evaluation teams. Consequently, the SEI developed a method for selecting among the candidate programs in a fair and impartial manner that also included pre-screening of programs to ensure readiness. In some cases, a QAW was conducted while a program prepared for an ATAM evaluation.

Similarly, the SEI developed a way of selecting ASSIP-trained individuals to participate on evaluation teams. These selection processes are discussed below.

The ASSIP paid the cost of the ATAM or QAW. Labor and TDY costs for Army personnel to participate on the teams were paid by either the PMO hosting the ATAM architecture evaluation or the individuals' home organization (or both). When qualified evaluators were not available from the PMOs under the cognizance of the associated PEO or supporting SEC, volunteers were sought from other external Army commands.

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[7] The Quality Attribute Workshop is described in a 2003 technical report [Barbacci 2003].

[SM] Quality Attribute Workshop and QAW are service marks of Carnegie Mellon University.

4.2.1 The ATAM Program Selection Process

Introducing new techniques into any environment increases risks for misunderstandings and poor outcomes. To minimize these risks, the authors of this report developed a process for selecting programs that focused on clearly communicating the requirements for receiving an ASSIP-sponsored ATAM to the PMOs and ensuring their commitment to proceed. In addition, the process sought to distribute ATAM opportunities as fairly as possible across PEOs. Figure 4 depicts the process.

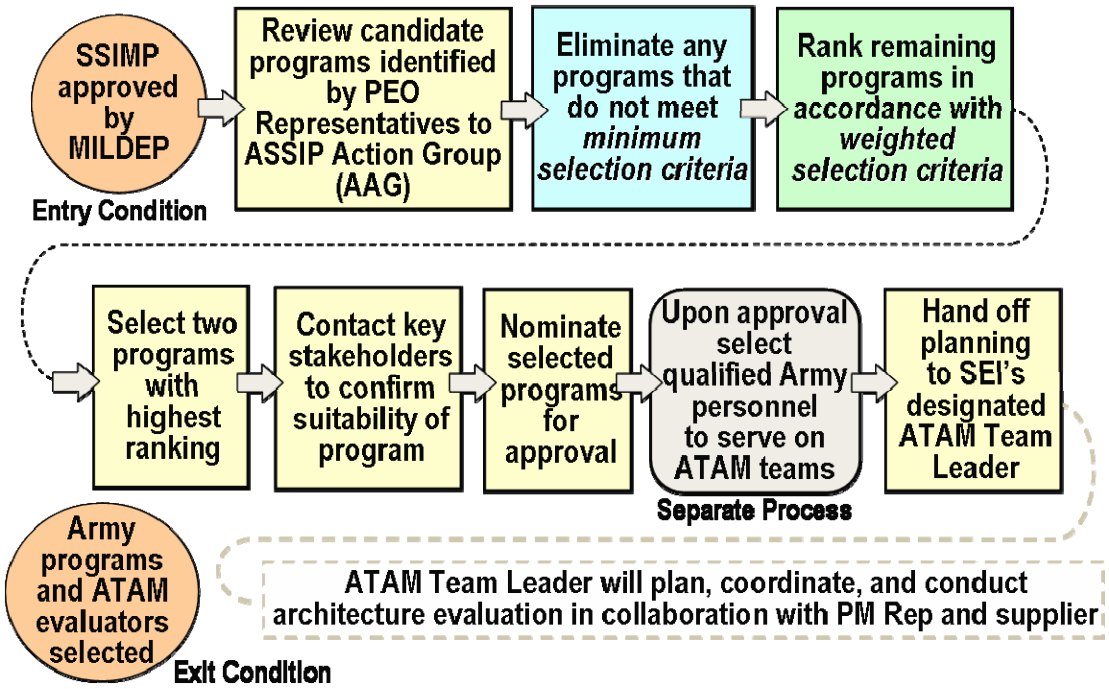

Figure 4: The Program Selection Process

Two senior SEI technical professionals, with experience in the ATAM evaluation requirements and familiarity with Army programs in general, contacted the designated representative for each program nominated by the AAG representatives to assess the extent to which the programs met the *minimum selection criteria*. Those that did not meet the minimum criteria were excluded from further consideration. The SEI staff members then ranked the remaining programs according to the *weighted selection criteria*.

Table 1 shows the minimum criteria and rationale. The minimum selection criteria reflect the basic ability of a PMO to commit to executing the process with the required program stakeholders and the availability of a documented software architecture for evaluation.

Table 1: Minimum Program Selection Criteria

Minimum Selection Criteria (Unweighted)	Rationale
PEO and PMO commitment	PEOs and PMOs must commit to actively participate in the evaluation
Availability of stakeholders	ATAM evaluations are stakeholder driven, thus stakeholders must be willing and able to participate
Availability of program artifacts and architecture documentation	An architecture must be documented to be evaluated
PMO/supplier can contractually accommodate ATAM engagement	If an architecture evaluation was not specified in the contract initially, the supplier and PMO must have some understanding to allow for the engagement to take place
Supplier commitment including availability of chief software architect	The architect must be available to describe the architecture and how it supports stakeholder needs

The weighted criteria, shown in Table 2, attempt to discriminate among candidates in part based on previous participation with the ASSIP or the SEI. To encourage broad application of architecture techniques, new participants were viewed more favorably in this regard. Additionally, programs were favored in instances where the anticipated payoff to the Army (as subjectively determined by the SEI) was relatively higher. Lastly, the ability to schedule an ATAM evaluation that met both program and SEI constraints also weighed in a program's favor. Appendix C depicts an example scoring sheet.

Table 2: Weighted Program Selection Criteria

Weighted Selection Criteria	Rationale
PEO first-time participant Yes = 5 / No = 0	To encourage broad participation, preference was given to organizations becoming involved in ASSIP-related improvement activities for the first time.
PEO or PMO is willing to pay travel costs for two Army evaluators Yes = 10 / No = 0	In the event that travel costs were associated with the participation of Army evaluation team members, preference was given to PMOs/PEOs that were willing to pay those expenses (or at least share them).
Program first-time participant Yes = 5 / No = 0	To encourage broad participation, preference was given to organizations becoming involved in ASSIP-related improvement activities for the first time.
Contractor first-time participant Yes = 5 / No = 0	To encourage wide exposure of architecture evaluation techniques, preference was given to programs whose prime contractor had no prior experience with such techniques.
Pay-off potential to Army 1 to 10, where 10 is highest favorable rating	Preference was given to programs that were especially critical to Army modernization efforts, since such programs had a great need to be architecturally cohesive with each other.
Opportune timing/scheduling 1 to 10, where 10 is highest favorable rating	Preference was given to programs that were able to commit to scheduling that was most compatible with availability of evaluation teams.

After selecting the two highest ranked programs, the SEI's technical staff confirmed each program's availability and commitment and then forwarded the programs for the concurrence of SEI management. Upon approval of the programs, the SEI staff began the process of selecting Army

personnel to participate on each team. Concurrently, SEI management assigned Lead Evaluators, who took charge of subsequent discussions with the selected programs.

Following successful completion of the selection process, the ATAM evaluations proceeded as usual, beginning with the Phase 0 discussions conducted by the ATAM team leader.

4.2.2 ATAM Team Member Selection Process

The selection process for Army team members followed a similar logic as the program selection process. Figure 5 depicts the personnel selection process.

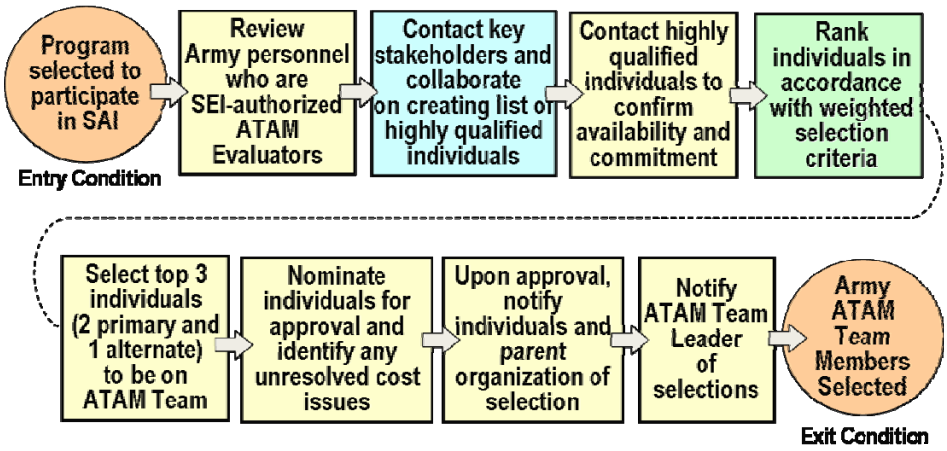

Figure 5: The Personnel Selection Process

The minimum requirements for any ATAM evaluation team member are successful completion of the *Software Architecture: Principles and Practices* and the *ATAM Evaluator Training* courses. However, since the ATAM evaluation is fundamentally a team-based method (not just in the sense of the evaluation team but also in the sense of the evaluators, the PMO, and the stakeholders), selecting evaluation team members becomes crucially important for the effective operation of the evaluation team and for the overall success of the evaluation. Consequently, the ASSIP instituted additional gating factors to help ensure that Army participants would be well matched both to the team and to the task.

As shown in Table 3, minimum criteria for participants emphasized technical competence in general architecture techniques as well as in the program domain, availability to participate (based on preliminary schedules), freedom from conflicts of interest, personal preparedness, and availability to assist in writing the final report.

Table 3: Minimum Personnel Selection Criteria

Minimum Selection Criteria	Rationale
Knowledgeable about domain	Individuals who have some knowledge of the technical domain can be more insightful about evaluating relevant architectures.
Software architecture expertise	Skill in developing software architectures is essential to being able to evaluate them.
Acceptable to key stakeholders	On very rare occasions, an evaluated program may perceive a given individual to be unacceptably biased.
Willing to be on ATAM Team and available in the time frame needed	Individuals must have both interest and availability to participate.
No known conflict of interest	Individuals must be free of conflicts of interest (including, but not limited to, participation in a competing program).
Army evaluator has laptop computer and understands follow-on commitment to assist in writing final report	Individuals must commit to being full participants on the team and come equipped with the resources to perform.

The weighted criteria shown in Table 4 favored individuals with a knowledge of the specific program. Positive feedback from an ATAM instructor also weighed in an individual's favor. As in the program selection process, new participants were favored, as were participants with a committed funding source. Lastly, individuals who had completed ATAM Leader training and who planned to become Lead Evaluators were favored because participation in an ATAM evaluation is one of the important criteria for becoming an ATAM Lead Evaluator.

Table 4: Weighted Personnel Selection Criteria

Weighted Selection Criteria	Rationale
Knowledgeable about program 1 to 10, where 10 is highest favorable rating	Individuals with some knowledge of the program can be even more insightful than those with domain knowledge.
Positive input from ATAM instructor 1 to 10, where 10 is highest favorable rating	Candidates who were deemed especially good students were preferred.
SEC or PM willing to pay labor costs Yes = 10 / No = 0	In the event that travel costs were associated with the participation of Army evaluation team members, preference was given to individuals' home organizations that were willing to pay those expenses (or at least share them).
SEC is first-time participant Yes = 5 / No = 0	To encourage broad participation, preference was given to individuals who represented SECs becoming involved in ASSIP-related improvement activities for the first time.
Individual and program associated with same PEO or SEC Yes = 5 / No = 0	To minimize the possibility of travel expenses, preference was given to individuals who belonged to the same organization that supported the program.
Completed ATAM Leader training Yes = 5 / No = 0	Individuals with a desire to become Lead Evaluators were given preference, since participating on an evaluation team is one of the prerequisites for that achievement.

The team member selection process followed a flow similar to that of the program selection process. The same SEI staff that selected the programs also selected the Army participants. The SEI

contacted the individuals directly as well as their home organizations as part of the screening process. Selected candidates were approved by SEI management and then assigned to teams.

Following their selection, Army team members participated fully in all evaluation team activities, including preparatory work, on-site evaluation, and post-evaluation report development.

Participation on an ATAM evaluation team is one of the steps individuals must complete prior to becoming an ATAM Lead Evaluator. Seven Army personnel have completed this step to date.

5 Progress to Date

Overall, the ASSIP SAI has succeeded in raising awareness within the Army acquisition community of the value of software architecture practices, particularly architecture evaluation. This section and the next address results, lessons learned, and ongoing work associated with the SAI.

5.1 RESULTS

As evidenced by the attendance, the software architecture training courses were very well received by the Army's technical professionals. A total of 64 Army personnel participated in the SAI training. Table 5 shows the total participation and number of certificate holders by organization at the time of training (some individuals have since changed organizations). These organizations and their certificate holders are now software architecture assets for themselves and for the broader Army acquisition community.

Table 5: Organizations with ASSIP-Trained Architecture Professionals

Organization	Certificates
Armaments Research, Development and Engineering Center Software Engineering Center (ARDEC SEC)	Total Participants: 9 7 ATAM Evaluators 7 Software Architecture Professionals
Aviation and Missile Research, Development, and Engineering Center Software Engineering Directorate (AMRDEC SED)	Total Participants: 11 9 ATAM Evaluators 7 Software Architecture Professionals
Communications-Electronics Lifecycle Management Command Software Engineering Center (C-E LCMC SEC)	Total Participants: 12 5 ATAM Evaluators 8 Software Architecture Professionals
Joint PEO Chemical and Biological Defense (JPEO CBD)	Total Participants: 2 1 Software Architecture Professional
PEO Ammunition (PEO Ammo)	Total Participants: 3 2 Software Architecture Professionals
PEO Aviation (PEO AVN)	Total Participants: 3 2 Software Architecture Professionals
PEO Command, Control and Communications Tactical (PEO C3T)	Total Participants: 5 1 ATAM Evaluator 3 Software Architecture Professionals
PEO Enterprise Information Systems (PEO EIS)	Total Participants: 1 1 Software Architecture Professional
PEO Ground Combat Systems (PEO GCS)	Total Participants: 2 1 ATAM Evaluator 1 Software Architecture Professional

Organization	Certificates
PEO Intelligence, Electronic Warfare and Sensors (PEO IEW&S)	Total Participants: 2 2 Software Architecture Professionals
PEO Missiles and Space (PEO MS)[8]	Total Participants: 4 2 Software Architecture Professionals
PEO Simulation, Training and Instrumentation (PEO STRI)	Total Participants: 2 2 Software Architecture Professionals
Tank-Automotive Research, Development and Engineering Center (TARDEC)	Total Participants: 8 7 ATAM Evaluators 4 Software Architecture Professionals

Note that, for a variety of reasons, not all participants were able to complete the course sequences required to earn a certificate.

Nine Army programs have benefited directly from the application of architecture evaluation methods. Table 6 shows the Army programs for which ATAM evaluations and QAWs have been conducted. The Common Avionics Architecture System (CAAS) and the Joint Tactical Common Operational Picture (COP) Workstation (JTCW) funded their evaluations directly rather than through the ASSIP, an indication of promulgation of software architecture techniques to the broader Army acquisition community.

Table 6: Army ATAM Evaluations and QAWs

Program/Project/Product	PEO	ASSIP Funded?	FY04	FY05	FY06
Manned/Unmanned Common Architecture Program (MCAP)	Aviation (AVN)	Yes	ATAM		
Aerial Common Sensor (ACS)	Intelligence, Electronic Warfare and Sensors (IEW&S)	Yes	ATAM		
Distributed Common Ground Station – Army (DCGS-A)	Intelligence, Electronic Warfare and Sensors (IEW&S)	Yes	QAW	ATAM	
Warfighter Information Network – Tactical (WIN-T)	Command, Control and Communications Tactical (C3T)	Yes		ATAM (2 Army Evaluators)	

[8] Participants were part of predecessor organizations PEO Tactical Missiles and PEO Air Space and Missile Defense.

Program/Project/Product	PEO	ASSIP Funded?	FY04	FY05	FY06
Common Avionics Architecture System (CAAS)	Aviation (AVN)	No		ATAM	
Integrated Fire Control (IFC)	Missiles and Space (MS)	Yes		QAW	ATAM (2 Army Evaluators)
One Semi-Automated Forces (OneSAF)	Simulation, Training and Instrumentation (STRI)	Yes			ATAM (1 Army Evaluator and 1 Army Observer)
Command Post of the Future (CPoF)	Command, Control and Communications Tactical (C3T)	Yes			ATAM (2 Army Evaluators)
Joint Tactical Common Operational Picture Workstation (JTCW)	Command, Control and Communications Tactical (C3T)	No			ATAM
Army Battle Command System (ABCS)	Command, Control and Communications Tactical (C3T)	No			QAW

A CASE STUDY

The detailed results of an ATAM evaluation are the property of the program office and further dissemination of the information is subject to the program manager's (PM)[9] discretion. In the case of the WIN-T program, the PM agreed to allow a published case study of the evaluation.

Participants in the WIN-T ATAM evaluation cited a number of benefits. Specifically, the ATAM evaluation helped WIN-T stakeholders develop an appreciation for the nature and importance of the program's software effort. In particular, the evaluation demonstrated the subtle complexities of the integration effort.

The ATAM evaluation brought to light several previously untracked technical and schedule risks that the program was then able to mitigate to reduce their likelihood and effect. Additionally, the evaluation led to a revision of the software architecture documentation to improve its clarity.

[9] This report makes no distinction among the roles of *program manager*, *project manager*, and *product manager*.

Participants also noted that the format of the ATAM evaluation provided a good opportunity for communication among a variety of program stakeholders, especially among software developers, stakeholders, and systems developers; between team partners; and among different groups of stakeholders.

Perhaps one of the best indications of the ATAM evaluation's value is that the WIN-T program manager chartered a software integrated product team (IPT) to continue the work of analyzing the software architecture and monitoring the evolving interests of the various stakeholders.

See [Clements 2005a] for the case study of the WIN-T software architecture evaluation.

5.2 LESSONS LEARNED

In addition to successes, there are several lessons to glean from the implementation of the ASSIP Software Architecture Initiative to date. The lessons fall into two categories: (1) those learned about barriers to developing an organic software architecture capability in the Army, and (2) those learned about instituting a software architecture improvement program.

5.2.1 Barriers to Software Architecture Practices

Those organizations acquiring software systems, communications systems, or electronics were more inclined to take full advantage of the SAI than those organizations that chiefly acquired weapons systems (even though the weapon systems were likely to contain significant amounts of software, communication, and electronic components). This was true principally of the programs nominated for ATAM evaluations; personnel interested in the architecture training were more evenly distributed across the various acquisition organizations.

The key difference between organizations appears to be that weapon systems acquirers tend to focus on big-picture system issues (e.g., the system in its totality); software is viewed as an *enabler* rather than a *driver* of system behavior. Organizations acquiring systems that have no function at all apart from that provided by the software had no difficulty in appreciating the need for software architecture evaluations. Similarly, the personnel from the software centers were twice as likely as PEO/PMO staffs to pursue and complete training as software architecture professionals. These outcomes suggest that special effort may be required to reach out to organizations that tend to treat software as a less important implementation detail in their systems.

5.2.2 Lessons About Implementing the Initiative

In the course of selecting among the nominated programs, it became apparent that some PMs were not fully aware of the conditions for being selected as a participating program in the ASSIP-sponsored ATAM evaluations. While all PMs of the nominated programs were eager to receive a free evaluation, some were initially unwilling to allow personnel from their PEO or SEC to participate, some objected to having Army personnel from unrelated or external commands on the team, and some were resistant to participation by *any* Army personnel. The SEI handled these objections through clarifying discussions during the personnel selection process. However, it is

apparent that there is a need for a written agreement describing the terms and conditions for program selection to ensure all parties have a common understanding of what is expected of programs that are selected.

Increasingly tight budgets frequently caused disagreements between PMOs and SECs over labor and TDY costs for Army participants on the ATAM evaluations, which greatly complicated the process for selecting Army team members. Sometimes, a cost sharing approach between the PMO receiving the ATAM and the SEC providing Army evaluators successfully ameliorated such difficulties. Another effective means of avoiding the problem was for prospective Army evaluators to include participation on an ATAM evaluation team as part of the training they proposed in their Individual (career) Development Plan (IDP). Such planning had the effect of guaranteeing that funds for participation would be available from the individual's home organization.

Setting appropriate expectations for team members and their organizations is vital. ATAM evaluations involve more than just on-site activities. Often, pre-evaluation teleconferences or meetings are needed to prepare and coordinate the evaluation team. In addition, taking part in development of a final evaluation report is an essential part of participating on an evaluation team. Although these points are included during the ATAM Evaluator training, sometimes they are overlooked if there is a lengthy period between taking the class and participating on a team. There were a couple of instances of misunderstanding about these points when recruiting participants for ASSIP-sponsored ATAM evaluations. While they were resolved rather easily, reinforcing the requirements for participation up front, which is now part of the recruitment process, is a better approach.

Flexibility in scheduling the ASSIP-sponsored ATAM evaluations was essential. The dynamic nature of programs can, and did, cause architecture evaluations to be rescheduled due to unexpected shifts in program priorities. Changes in program scope and schedule also result in delay or even cancellation of planned evaluations. It is advisable to have alternate programs as a backup if possible.

The entire software architecture curriculum, including the ATAM Lead Evaluator course, was offered as part of the architecture initiative. However, as discussed further in Section 6.1, becoming a Lead Evaluator requires satisfaction of several criteria beyond simply attending the course. Through the initiative, individuals were allowed to take the ATAM Lead Evaluator course without consideration for their organizations' commitment to follow through with these additional steps. The Lead Evaluator course should have been delayed and offered only to those individuals who not only had an interest in becoming Lead Evaluators but who had the support of their organizations in satisfying all the criteria.

6 Ongoing Work

Based on successes and lessons learned to date, the ASSIP continues to focus on software architecture capability within the Army. The sections below describe the ongoing tasks.

6.1 ATAM LEAD EVALUATOR SELECTION PROCESS

The success of any ATAM evaluation is largely dependent on the Lead Evaluator's ability to make technical assessments, to lead the evaluation team, and to manage the stakeholders of the architecture in question. Thus, the role of Lead Evaluator is pivotal, and the stringent requirements of the selection process help ensure that only fully qualified individuals progress to the level of ATAM Lead Evaluator.

ATAM Lead Evaluators require not only specialized technical skills in the development and evaluation of software architectures, but also leadership skills. Not all technical professionals will posses the requisite talents to be successful ATAM Lead Evaluators. Consequently, becoming an SEI-authorized ATAM Lead Evaluator involves more than simply taking the Lead Evaluator class. Individuals must complete all of the software architecture courses, participate as an evaluator on an ATAM evaluation team, and apply for and successfully complete an observation as a Lead Evaluator. The observation requires a special fee.

Becoming a Lead Evaluator is not a trivial process, and not all candidates will be successful because of the special combination of skills that must be demonstrated. Since it is possible to go through all the steps in the process without guarantee of success, becoming a Lead Evaluator requires not just the desire of an individual but also the commitment of the sponsoring organization. Making this commitment explicit and up front was viewed as vital for Army candidates to be successful. To address this need, the SEI developed a detailed explanation of the process and an endorsement form specifically for Army personnel seeking to become Lead Evaluators. The endorsement form makes clear a sponsor's support of an individual's candidacy. Appendix D elaborates the process and qualifications for an Army ATAM Lead Evaluator. Appendix E shows a sample Lead Evaluator endorsement form.

As of this writing, two Army personnel who are SEI-authorized ATAM Evaluators and have completed the Lead Evaluator training course have begun the process to become SEI-authorized ATAM Lead Evaluators.

6.2 SOFTWARE PRODUCT LINES

Closely related to software architecture practices is the notion of software product lines. As the name suggests, software product line practices seek to apply production line manufacturing concepts to software development via pre-planned, strategic software reuse. A software product line

approach can yield quantitative gains in productivity and product quality [SEI 2006], as well as reductions in development costs.

For example, the software product line implementation for the U.S. Army's Common Avionics Architecture System (CAAS), which was not ASSIP funded, resulted in a number of benefits jointly cited by the Army's Technical Applications Program Office (TAPO) and by the CAAS prime contractor. Chief among those benefits are projected cost savings of *several million dollars* [Clements 05b]. The program also anticipates substantial improvement in deployment time over previous systems and has been able to achieve real, strategic software reuse as high as 80 percent [Clements 05b]. General guidance for decision makers in DoD organizations on product line acquisition is described in [Bergey 2006].

Based on the success of the CAAS product line effort, the AAG elected to add SEI's software product line course to the ASSIP curriculum. The curriculum consists of the following courses:

- *Software Product Lines*
- *Adopting Software Product Lines*
- *Developing Software Product Lines*
- *Product Line Technical Probe*[SM] *Team Training*

The *Software Product Lines* course also is part of the original software architecture curriculum, so many Army students already had it under their belts.

The software product line curriculum was offered in a manner similar to that of the software architecture curriculum. As a follow-on activity in FY07, the ASSIP will sponsor three product line workshops to allow programs to share their lessons learned from implementing product line architectures and encourage further implementation of product line techniques in the acquisition of systems of systems.

6.3 ASSESSING PROGRESS

A key to any improvement effort is a periodic assessment of progress. To that end, the FY07 SSIMP includes a task that will assess how well the ASSIP architecture work to date has permeated Army software engineering practices. The ASSIP will conduct a software architecture workshop aimed at determining the investment and additional actions needed to build and sustain a truly organic software architecture capability within the Army. This workshop will be a hands-on meeting in which participants will

- learn about best practices and recent developments in software architecture
- share Army experiences in using software architecture practices, in particular the Architecture Tradeoff Analysis Method (ATAM) and Quality Attribute Workshop (QAW)

[SM] Product Line Technical Probe is a service mark of Carnegie Mellon University.

- discuss ways in which the original objective of the ASSIP Army Software Architecture Initiative can be achieved
- examine barriers and enablers to much broader adoption of software architecture practices within the Army
- determine the steps needed to make software architecture practices standard practice across the Army

The two-day event will produce an understanding of the current state of practice within the Army regarding software architecture and will identify opportunities for building on the work done so far through the ASSIP and the efforts of individual programs.

7 Summary

The Army recognizes the importance of software architecture to its software-intensive systems acquisitions. The complexity of modern weapon, communication, and information systems demands a rigorous understanding and application of software architecture techniques to reduce risk in the acquisition of software-intensive systems and to increase the likelihood of successful outcomes.

Through several surveying techniques, the ASSIP discovered that the Army's ability to judge the software architecture practices and products of their contractors was lacking, while Army acquisition professionals did not feel their contractor's software architecture techniques were particularly exemplary. This dichotomy led to the creation of the ASSIP software architecture initiative.

To date, 64 Army technical personnel have received software architecture training through the ASSIP SAI. Several of them have augmented their training with participation on ATAM evaluations.

Table 7: Architecture Training Synopsis – PEO Staff (including subordinate PMOs)[10]

Course in Software Architecture Curriculum	Number of Army Personnel Trained											
	Ammo	AVN	C3T	CBD	CS& CSS	EIS	GCS	IEW&S	MS	Soldier	STRI	Total
Software Architecture: Principles and Practices	3	2	4	1	0	1	2	2	3	0	2	20
Documenting Software Architectures	2	2	4	2	0	1	2	2	3	0	2	20
Software Architecture Design and Analysis	3	2	3	1	0	1	2	2	2	0	2	18
Software Product Lines	2	2	3	1	0	1	2	2	2	0	2	17
ATAM Evaluator Training	0	0	1	0	0	0	1	0	0	0	0	2
ATAM Leader Training	0	0	1	0	0	0	1	0	0	0	0	2

[10] At the time of training; some individuals have since changed organizations.

Table 8: Architecture Training Synopsis – SEC Staff

Course in Software Architecture Curriculum	Number of Army Personnel Trained				
	AMRDEC SED	ARDEC SEC	C-E LCMC SEC	TARDEC	Total
Software Architecture: Principles and Practices	8	9	9	6	32
Documenting Software Architectures	8	8	9	6	31
Software Architecture Design and Analysis	8	8	9	6	31
Software Product Lines	6	7	8	4	25
ATAM Evaluator Training	10	7	6	7	30
ATAM Leader Training	6	6	3	4	19

In addition, seven major Army programs have benefited from undergoing ATAM evaluations. Early qualitative results indicate that evaluations are useful in discovering significant technical, schedule, and programmatic risks while also providing a forum for increased and improved communication between and among developers and stakeholders of the system.

Ongoing efforts to build the Army's organic ability to apply software architecture practices now include ASSIP-sponsored training in software product lines, which is an advanced concept in strategic software reuse that requires an architecture-centric approach. Moreover, a few Army personnel want to pursue SEI authorization as ATAM Lead Evaluators, which, if completed successfully, will allow them to plan, organize, and conduct ATAM evaluations for the Army.

Thus, the Army is on its way toward developing a culture that supports software architecture practices, and especially architecture evaluation, as a valuable tool in ensuring program success while simultaneously evolving an organic capability to perform such evaluations through its technical personnel.

Feedback

Through its Acquisition Support Program (ASP), the Carnegie Mellon Software Engineering Institute (SEI) is working to help improve the acquisition of software-intensive systems across the U.S. government. As part of its mission, the SEI is pleased to discuss the information presented here in more detail. The SEI is especially eager to hear about experiences with software architecture practices in the other services.

Please send questions or comments about this report to the authors:

- Stephen Blanchette, Jr. (sblanche@sei.cmu.edu)
- John Bergey (jkb@sei.cmu.edu)

For more information about the SEI's software architecture technology or software product line technology, including the respective curricula, please contact Linda Northrop (lmn@sei.cmu.edu), director, Product Line Systems Program.

For additional ASSIP information, please contact the SEI Chief Software Engineer for Army Programs, Cecilia Albert (cca@sei.cmu.edu).

Appendix A Acronyms and Abbreviations

The alphabetical list below contains the acronyms, abbreviations, and their meanings as used in this report.

AAG
ASSIP Action Group

ABCS
Army Battle Command System

ACS
Aerial Common Sensor

AKO
Army Knowledge Online

Ammo
Ammunition

AMRDEC
Aviation and Missile Research, Development, and Engineering Center

ARDEC
Armaments Research, Development & Engineering Center

ASA(ALT)
Assistant Secretary of the Army for Acquisition, Logistics, and Technology

ASP
Acquisition Support Program

ASSIP
Army Strategic Software Improvement Program

ATAM
Architecture Tradeoff Analysis Method

ATEC
Army Test and Evaluation Command

AVN
Aviation

BFI
Benchmarking for Improvement

C3T
Command, Control and Communications Tactical

CAAS
Common Avionics Architecture System

CBD
Chemical and Biological Defense

C-E LCMC
Communications-Electronics Lifecycle Management Command

CPoF
Command Post of the Future

CS&CSS
Combat Support and Combat Service Support

DACS
Data and Analysis Center for Software

DAU
Defense Acquisition University

DCGS-A
Distributed Common Ground Station – Army

DoD
Department of Defense

DSB
Defense Science Board

DTIC
Defense Technical Information Center

EIS
Enterprise Information Systems

ESC
Electronic Systems Center

FY
Fiscal Year

GAO
Government Accountability Office

GCS
Ground Combat Systems

IDP
Individual Development Plan

IEPR
Independent Expert Program Review

IEW&S
Intelligence, Electronic Warfare and Sensors

IFC
Integrated Fire Control

IPT
Integrated Product Team

JPEO
Joint Program Executive Office

JTCW
Joint Tactical Common Operational Picture Workstation

MCAP
Manned/Unmanned Common Architecture Program

MILDEP
Military Deputy

MS
Missiles and Space

OneSAF
One Semi-Automated Forces

PEO
Program Executive Officer
Program Executive Office

Pgm
Program

PM
Program Manager
Project Manager
Product Manager

PMO
Program Management Office

QAW
Quality Attribute Workshop

Rep
Representative

SAI
Software Architecture Initiative

SEC
Software Engineering Center

SED
Software Engineering Directorate

SEI
Software Engineering Institute

SIS
Software-intensive systems

SR
Special report

SSG
Senior Steering Group

SSIMP
Strategic Software Improvement Master Plan

STRI
Simulation, Training and Instrumentation

TAI
Tri-Service Assessment Initiative

TAPO
Technical Applications Program Office

TARDEC
Tank-Automotive Research, Development & Engineering Center

TDY
Temporary Duty

TN
Technical note

TR
Technical report

TRADOC
Training and Doctrine Command

URL
Universal Resource Locator

U.S.
United States

USAAA
United States Army Audit Agency

WIN-T
Warfighter Information Network – Tactical

Appendix B Overview of ATAM Evaluation Method

The purpose of the ATAM is to assess the consequences of architectural decision alternatives in light of quality attribute requirements [Kazman 2000]. The major goals of the ATAM are to

- elicit and refine a precise statement of the architecture's driving quality attribute requirements
- elicit and refine a precise statement of the architectural design decisions
- evaluate the architectural design decisions to determine if they satisfactorily address the quality requirements

The ATAM is predicated on the fact that an architecture is suitable (or not suitable) only in the context of specific quality attributes that it must impart to the system. The ATAM uses stakeholder perspectives to produce a collection of scenarios that define the qualities of interest for the particular system under consideration. Scenarios give specific instances of usage, performance requirements, growth requirements, various types of failures, various possible threats, and various likely modifications. Once the important quality attributes are identified in detail, then the architectural decisions relevant to each one can be illuminated and analyzed with respect to their appropriateness.

The ATAM steps are carried out in two main phases. In the first, the evaluation team interacts with the system's primary decision makers: the architect(s), manager(s), and perhaps a marketing or customer representative. During the second phase, a larger group of stakeholders is assembled, including developers, testers, maintainers, administrators, and users. The two-phase approach insures that the analysis is based on a broad and appropriate range of perspectives.[11]

Phase 1:

1. **Present the ATAM.** The evaluators explain the method so that those who will be involved in the evaluation have an understanding of the ATAM process.
2. **Present the business drivers.** Appropriate system representative(s) present an overview of the system, its requirements, business goals, context, and the architectural quality drivers.
3. **Present the architecture.** The system or software architect (or another lead technical person) presents the architecture.
4. **Catalog the architectural approaches.** The system or software architect presents general architectural approaches to achieve specific qualities. The evaluation team captures a list and adds to it any approaches they saw during Step 3 or learned during their pre-exercise review

[11] These two phases are sandwiched by two less intensive phases. Phase 0 is a preparation phase in which the evaluation activities are planned and set up. Phase 3 is a follow-up phase in which the final report is produced and opportunities for improving the process are considered.

of the architecture documentation. For example, “A cyclic executive is used to ensure real-time performance.” Known architectural approaches have known quality attribute properties, and these will help in carrying out the analysis steps.

5. **Generate a quality attribute utility tree.** Participants build a utility tree, which is a prioritized set of detailed statements about what quality attributes are most important for the architecture to carry (such as performance, modifiability, reliability, or security) and specific scenarios that express these attributes.
6. **Analyze the architectural approaches.** The evaluators and the architect(s) map the utility tree scenarios to the architecture to see how it responds to each important scenario.

Phase 2:

Phase 2 begins with an encore of the Step 1 ATAM presentation and a recap of the results of Steps 2 through 6 for the larger group of stakeholders. Then

1. **Brainstorm and prioritize scenarios.** The stakeholders brainstorm additional scenarios that express specific quality concerns. After brainstorming, the group chooses the most important ones through a voting process.
2. **Analyze the architectural approaches.** As in Step 6, the evaluators and the architect(s) map the high-priority, brainstormed scenarios to the architecture.
3. **Present the results.** A presentation and final report are produced that capture the results of the process and summarize the key findings.

Scenario analysis produces the following results:

- a collection of sensitivity and tradeoff points. A sensitivity point is an architectural decision that affects the achievement of a particular quality. A tradeoff point is an architectural decision that affects more than one quality attribute (possibly in opposite ways).
- a collection of risks and non-risks. A risk is an architectural decision that is problematic in light of the quality attributes that it affects. A non-risk is an architectural decision that is appropriate in the context of the quality attributes that it affects.
- a list of issues and a list of decisions not yet made. Often during an evaluation, issues not directly related to the architecture arise. These may have to do with an organization’s processes, personnel, or other special circumstances. The ATAM process records these so that they may be addressed by other means. The list of decisions not yet made arises from the stage of the life cycle of the evaluation. An architecture represents a collection of decisions. Not all relevant decisions may have been made at the time of the evaluation, even when designing the architecture. Some of these decisions are known to the development team as having not been made and are on a list for further consideration. Others are news to the development team and stakeholders.

Results of the overall exercise also include the summary of the business drivers, the architecture, the utility tree, and the analysis of each chosen scenario. All of these results are recorded visibly so that all stakeholders can verify they have been correctly identified.

The number of scenarios analyzed during the evaluation is controlled by the amount of time allowed for the evaluation, but the process insures that the most important ones are addressed.

After the evaluation, the evaluators write a report documenting the evaluation and recording the information discovered. This report will also document the framework for ongoing analysis discovered by the evaluators. A detailed description of the ATAM process can be found in [Kazman 2000] and [Clements 2002].

Appendix C Example Program Selection Score Sheet

Figure 6 depicts an example of a scoring sheet for selecting programs to receive an ASSIP-sponsored ATAM evaluation. Failure to meet minimum criteria results in a net score of zero regardless of other factors. In the example depicted, the inability to confirm fictional Program 7's compliance with the minimum criteria prevented it from achieving a score of at least 25 and therefore being selected as one of the programs to receive an ATAM evaluation.

			ASSIP Scoring for ATAM Engagements						
		PEO	PEO-A	PEO-B	PEO-C	PEO-A	PEO-D	PEO-D	PEO-E
		Program	Pgm1	Pgm2	Pgm3	Pgm4	Pgm5	Pgm6	Pgm7
		Contractor	C1	C2	C3	C4	C5	C6	C7
MINIMUM Criteria	PEO/Program Commitment	See Legend below	✔	✔	?	✕	✕	?	?
	Stakeholders Available	See Legend below	✔	✔					?
	Artifacts Available	See Legend below	✔	✔					?
	Contractual Accomodation	See Legend below	✔	✔	✕			✕	?
	Supplier Commitment	See Legend below	✔	✔	?				?
	AAG & Program Reps follow through	See Legend below	✔	✔	✕			✔	?
WEIGHTED Criteria	1st-Time PEO	5 (Yes) 0 (No)	0	0	0	0	5	0	5
	PEO/PM/SEC Pays Army Evaluator Labor/Travel	10 (Yes) 0 (No)	TBD	10	0	0			
	1st-Time Program	5 (Yes) 0 (No)	0	5	0	0	5	5	5
	1st-Time Contractor	5 (Yes) 0 (No)	5	2.5	0	5			5
	Pay-off to Army	1 to 10	7	10	5	5		8	10
	Opportune Scheduling	1 to 10	10	7				0	
	SCORE (If MINIMUM Criteria satisfied)		22	34.5	0	0	0	0	0

LEGEND	
Appears to comply	✔
Compliance questionable	?
Compliance not apparent	✕

Figure 6: Example of a Scoring Sheet for Selecting Programs

EXAMPLE

Appendix D ATAM Lead Evaluator Criteria for Army Candidates

Qualifications and Procedure to become an Army Lead ATAM Evaluator

To qualify as an SEI-authorized ATAM Lead Evaluator, an Army candidate must complete the following steps:

1. **Obtain an ATAM Evaluator Certificate** by completing the following two courses:
   - Software Architecture: Principles and Practices
   - ATAM Evaluator Training

2. **Complete the following courses** from the SEI Software Architecture Curriculum:
   - Documenting Software Architectures
   - Software Architecture Design and Analysis

3. **Participate as an ATAM Evaluator** on at least one ATAM evaluation team for an Army program and receive a positive endorsement from the ATAM team leader.
   [Note: Step 3 may be completed before Step 2.]

4. **Obtain management endorsement** to become an Army Lead ATAM Evaluator from your immediate supervisor or organizational sponsor
   [This step of the process is unique to the Army. A template for the endorsement is available upon request from Stephen Blanchette <sblanche@sei.cmu.edu> or John Bergey <jkb@sei.cmu.edu> of the SEI.]

5. **Complete a preparatory leadership training course** after obtaining endorsement:
   - ATAM Leader Training

6. **Submit an Application for ATAM Observation*** to the SEI for approval. The purpose of an ATAM Observation is to enable an experienced ATAM Lead Evaluator from the SEI (the Observer) to observe and evaluate a candidate ATAM Lead Evaluator (the Candidate) as he or she conducts a software architecture evaluation using the ATAM.
   [An application form is available upon request from Larry Jones <lgj@sei.cmu.edu> of the SEI.]

7. **Lead a software architecture evaluation using the ATAM** while being observed. The Observer will rate the Candidate's performance during the evaluation and submit an observation report to the SEI ATAM Board with a recommendation whether or not the Candidate should receive the SEI ATAM Lead Certificate.

8. **Upon recommendation of the SEI ATAM Board**, the Candidate will be awarded an SEI **Lead ATAM Evaluator Certificate**.

* There is a fee associated with an ATAM Observation. Payment of the fee does not guarantee the candidate will receive the SEI ATAM Lead Evaluator Certificate. The SEI ATAM Board will decide the outcome of the Observation and notify the candidate.

Version 1.1, 8 December 2005

Appendix E Army ATAM Lead Evaluator Endorsement Form

ENDORSEMENT FORM
Army Candidates for ATAM Lead Evaluator

INSTRUCTIONS: Fill in highlighted fields and print on office letterhead. Alternatively, retype on office letterhead. Return completed and signed endorsement forms to: ***Ceci Albert, Software Engineering Institute, NRECA Building, Suite 200, 4301 Wilson Boulevard, Arlington, VA 22203***

Date:

Applicant's Full Name:
Organization:
Email Address:
Telephone:

Sponsor's Full Name:
Organization:
Email Address:
Telephone:

Sponsor's Role (check one): ☐ Immediate Supervisor ☐ Organizational Sponsor

I hereby endorse the above named applicant as a candidate to be an Architecture Tradeoff Analysis Method (ATAM) Lead Evaluator for the US Army. I understand that SEI certification as an ATAM Lead Evaluator is contingent upon the following requirements with which I concur as noted.

Concur	Non-Concur	
		Candidates must complete all the course requirements including the ATAM Leader Training course
		Candidate must participate in an ATAM evaluation as an ATAM Evaluator and receive a positive endorsement from the ATAM Team Leader.
		Candidate must have significant experience in designing and developing software-intensive systems and some familiarity with modern software engineering concepts
		Candidates must submit an application to the SEI for approval to be observed as a Lead Evaluator
		Candidates must pay a fee for the ATAM Observation engagement
		Candidates must successfully lead an architecture evaluation using the ATAM and receive a favorable observation report

I further understand that due to the unique combination of technical and facilitation skills required of Lead Evaluators, *not all candidates will be successful*. The SEI ATAM Board has sole and final responsibility for determining successful completion of all criteria.

_____
(Signature)

Job Title:

Version 1.1, 8 December 2005

SAMPLE

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13. ABSTRACT (MAXIMUM 200 WORDS)

The goal of the United States Army Strategic Software Improvement Program is to dramatically improve the acquisition of software-intensive systems. One of the initiatives undertaken by the program is to begin building a level of technical expertise in modern software architecture practices within the Army acquisition community.

This report describes the Software Architecture Initiative of the Army Strategic Software Improvement Program. Results to date are encouraging and serve as a guide for other acquisition organizations seeking to strengthen their technical competencies.

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