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Report to the Chairman and Ranking Member, Subcommittee on Readiness and Management Support, Committee on Armed Services, U.S. Senate

March 2001

DOD INFORMATION TECHNOLOGY

Software and Systems Process Improvement Programs Vary in Use of Best Practices

GAO-01-116

Contents

Abbreviations

AFA	Air Force Academy
AFCA	Air Force Communications Agency
AMC	Army Materiel Command
AMCOM	Aviation and Missile Command
CECOM	Communications-Electronics Command
CIO	chief information officer
CMMI[SM]	Capability Maturity Model Integration[SM]
DFAS	Defense Finance and Accounting Service
DLA	Defense Logistics Agency
DOD	Department of Defense
FSO	Financial Systems Organization
IDEAL[SM]	initiating, diagnosing, establishing, acting, and leveraging
ITD	Information and Technology Directorate
MCTSSA	Marine Corps Tactical Systems Support Activity
MSG	Materiel Systems Group
NAVAIR	Naval Aviation Systems Command
OSD	Office of the Secretary of Defense
SEC	Software Engineering Center
SED	Software Engineering Directorate
SEI	Software Engineering Institute
SEO	systems engineering organizations
SEPG	software engineering process group
SPAWAR	Space and Naval Warfare Systems Command
SSC	SPAWAR Systems Center
SSG	Standard Systems Group
SW-CMM®	Software Capability Maturity Model®
SPI	software/systems process improvement

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United States General Accounting Office
Washington, D.C. 20548

March 30, 2001

The Honorable James M. Inhofe
Chairman
The Honorable Daniel K. Akaka
Ranking Member
Subcommittee on Readiness and
Management Support
Committee on Armed Services
United States Senate

With an annual information technology budget of about $20 billion, and tens of billions more budgeted for technology embedded in sophisticated weaponry, the Department of Defense (DOD) relies heavily on software-intensive systems to support military operations and associated business functions, such as logistics, personnel, and financial management. One important determinant of the quality of these systems, and thus DOD's mission performance, is the quality of the processes used to develop, acquire, and engineer them. Recognizing the importance of these processes to producing systems that perform as intended and meet cost and schedule commitments, successful public and private organizations have adopted and implemented software/systems process improvement (SPI) programs.[1]

[1]As used in this report, SPI refers to improvements in software development, software acquisition, and systems engineering. Software development refers to activities an organization uses to build and maintain software, while software acquisition refers to activities an organization uses to obtain software developed by another organization. Systems engineering refers to activities an organization uses to define, develop, and maintain systems.

This report is part of our response to your request to compare and contrast DOD information technology practices with leading practices. In particular, you asked us to review DOD components' (military services and Defense agencies) SPI management activities to ensure that DOD is taking the necessary steps to continuously strengthen its software and systems development, acquisition, and engineering processes. As agreed with your offices, our objectives were to (1) compare selected DOD components' SPI programs against Carnegie Mellon University's Software Engineering Institute's (SEI)[2] IDEAL[SM][3] model, which is a recognized best practices model, (2) determine how these components have approached management of their SPI programs, and (3) determine what DOD-wide efforts are under way to promote and leverage the components' SPI programs. The components that we selected were the Departments of the Army, Air Force, and Navy; the Marine Corps; the Defense Logistics Agency (DLA); and the Defense Finance and Accounting Service (DFAS).

Because Army, Navy, and Air Force do not manage SPI centrally and have delegated SPI responsibility to their respective subordinate organizational units, we selected at least two of the largest of these units within each service to review. Accordingly, all references in this report to the respective services' SPI programs refer only to the subordinate units that we reviewed. We performed our work from March through December 2000, in accordance with generally accepted government auditing standards. (See appendix I for details of our objectives, scope, and methodology, including the specific service units reviewed.) DOD provided us with written comments on a draft of this report. These comments are summarized in the "Agency Comments and Our Evaluation" section of this letter and are reproduced in full in appendix II.

Background

DOD maintains a force of about 3 million military and civilian personnel worldwide. To protect the security of the United States, the department relies on a complex array of computer-dependent and mutually supportive organizational components, including the military services and Defense agencies. It also relies on a broad array of computer systems, including

[2]SEI is a nationally recognized, federally funded research and development center established at Carnegie Mellon University to address software engineering practices.

[3]IDEAL[SM] is a service mark of Carnegie Mellon University and stands for initiating, diagnosing, establishing, acting, and leveraging.

weapons systems, command and control systems, satellite systems, inventory management systems, financial systems, personnel systems, payment systems, and others. Many of these systems in turn are connected with systems operated by private contractors, other government agencies, and international organizations.

DOD's ability to effectively manage information technology is critical to its ability to accomplish its mission. Its reliance on software-intensive systems to support operations related to intelligence, surveillance, security, and sophisticated weaponry—along with financial management and other business functions—will only increase as the department modernizes and responds to changes in traditional concepts of warfighting.

The scope of DOD's information technology inventory is vast: over 1.5 million computers, 28,000 systems, and 10,000 computer networks. Further, many of DOD's most important technology projects continue to cost more than projected, take longer to produce, and deliver less than promised.[4] As a result, we have designated DOD systems development and modernization efforts as a high-risk area.[5]

The quality of the processes involved in developing, acquiring, and engineering software and systems has a significant effect on the quality of the resulting products. Accordingly, process improvement programs can increase product quality and decrease product costs. Public and private organizations have reported significant returns on investment through such process improvement programs. SEI has published reports of benefits realized through process improvement programs. For example, SEI reported in 1995[6] that a major defense contractor implemented a process improvement program in 1988 and by 1995 had reduced its rework costs from about 40 percent of project cost to about 10 percent, increased staff productivity by about 170 percent, and reduced defects by about 75 percent. According to a 1999 SEI report,[7] a software development contractor reduced its average deviation from estimated schedule time

[4] *Observations on the Department of Defense's Fiscal Year 1999 Performance Report and Fiscal Year 2001 Performance Plan* (GAO/NSIAD-00-188R, June 30, 2000).

[5] *High-Risk Series: An Update* (GAO/HR-99-1, January 1999).

[6] Technical Report CMU/SEI-95-TR-017, November 1995.

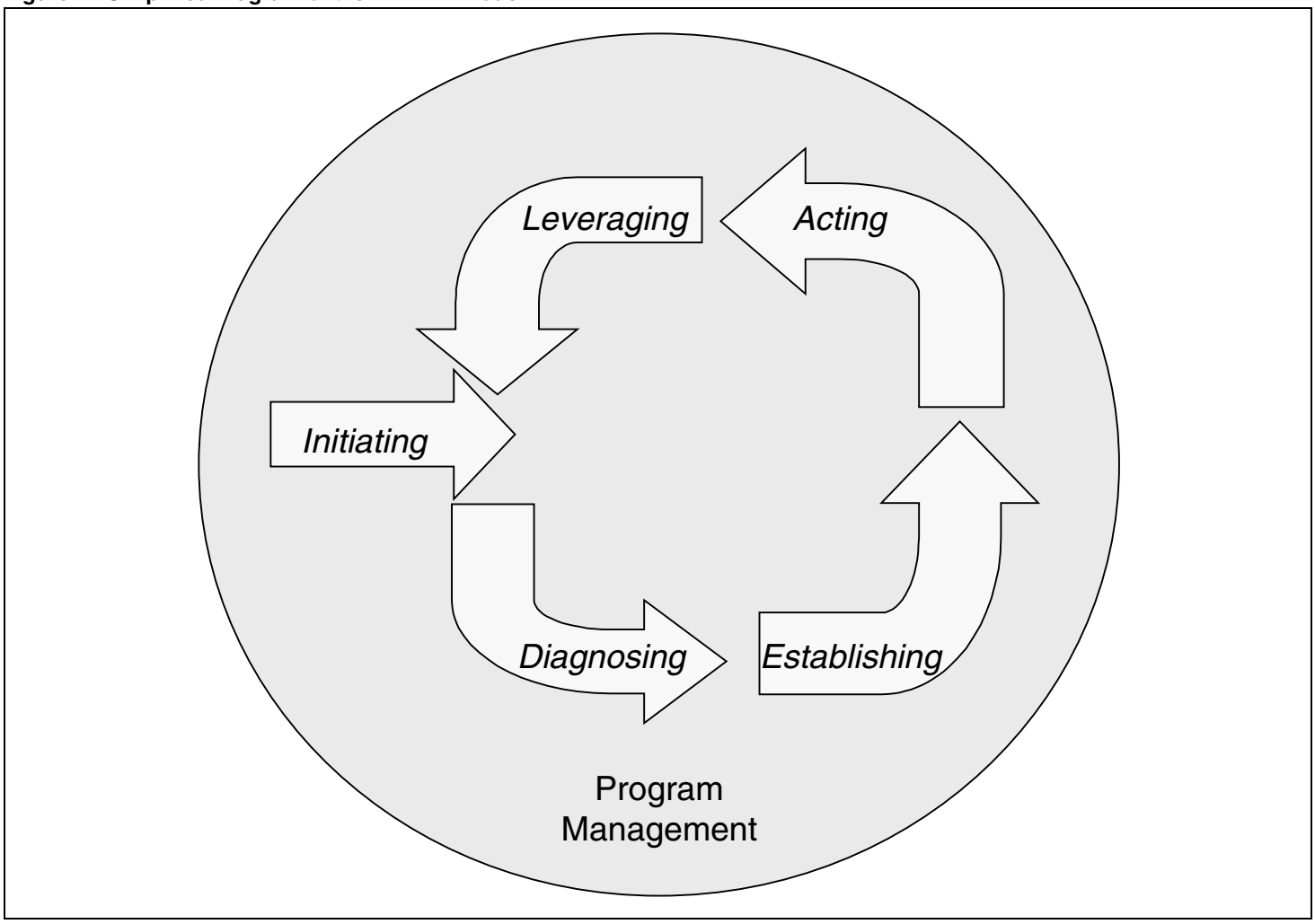
[7] Technical Report CMU/SEI-99-TR-027, November 1999.

from 112 percent to 5 percent between 1988 and 1996. During the same period, SEI reported that this contractor reduced its average deviation from estimated cost from 87 percent to minus 4 percent.

To aid organizations attempting to initiate and manage SPI programs, SEI has published a best practices model called IDEAL,[SM] which defines a systematic, five-phase, continuous process improvement approach, with a concurrent sixth element addressing the program management tasks spanning the five phases[8] (see figure 1).

[8] *IDEAL[SM]: A User's Guide for Software Process Improvement* (CMU/SEI-96-HB-001).

Figure 1: Simplified Diagram of the IDEAL[SM] Model



Source: GAO based on handbook CMU/SEI-96-HB-001.

- **Initiating:** During this phase, an organization establishes the management structure of the process improvement program, defines and assigns roles and responsibilities, allocates initial resources, develops a plan to guide the organization through the first three phases of the program, and obtains management approval and funding. Two key organizational components of the program management structure established during this phase are a management steering group and a software engineering process group (SEPG). Responsibility for this phase rests with senior management.

- **Diagnosing:** During this phase, the SEPG appraises the current level of process maturity[9] to establish a baseline capability against which to measure progress and identifies any existing process improvement initiatives. The SEPG then uses the baseline to identify weaknesses and target process improvement activities. It also compares these targeted activities with any ongoing process improvement activities and reconciles any differences. Responsibility for this phase rests primarily with line managers and practitioners.
- **Establishing:** During this phase, the SEPG prioritizes the process improvement activities and develops strategies for pursuing them. It then develops a process improvement action plan that details the activities and strategies and includes measurable goals for the activities and metrics for monitoring progress against goals. Also during this phase, the resources needed to implement the plan are committed and training is provided for technical working groups, who will be responsible for developing and testing new or improved processes. Responsibility for this phase resides primarily with line managers and practitioners.
- **Acting:** During this phase, the technical working groups, formed under the establishing phase, create and evaluate new and improved processes. Evaluation of the processes is based on pilot tests that are formally planned and executed. If the tests are successful, the working groups develop plans for organization-wide adoption and institutionalization, and once approved, execute them. Responsibility for this phase resides primarily with line managers and practitioners.
- **Leveraging:** During this phase, results and lessons learned from earlier phases are assessed and applied, as appropriate, to enhance the structures and plans of process improvement programs. Responsibility for this phase rests primarily with senior management.

The model's sixth element, continuous program management, specifies management structures and tasks for planning, organizing, directing, staffing, and monitoring the program. Responsibility for this element rests with senior management.

[9]SEI has developed process maturity models for software development, software acquisition, and systems engineering, as well as an integrated model for improving software development, acquisition, and maintenance. (See appendix III for information on these models.)

Each phase of the IDEAL[SM] model contains several recommended tasks. Appendix I, which describes our objectives, scope, and methodology, identifies all tasks for each phase.

Results in Brief

The DOD components that we reviewed vary in how they compare to SEI's IDEAL[SM] model. In particular, the Air Force, Army, and DFAS generally satisfied the model's recommended tasks, as did certain Navy units. However, DLA, the Marine Corps, and other Navy units did not. Specifically, DLA does not have an SPI program, although during the course of our review the DLA Chief Information Officer stated that she intends to establish one. Further, although the Marine Corps is performing many SPI activities, core tasks associated with an effective SPI program, such as a plan of action or dedicated resources to implement recommended improvements, are missing. Finally, certain Navy units also do not have SPI programs aligned with the IDEAL[SM] model, although one is performing a few of the model's recommended tasks.

The four components with SPI programs (Army, Air Force, DFAS, and parts of the Navy) are using different management strategies for directing and controlling their respective programs. Nonetheless, all components with SPI programs report that they have realized benefits in product quality and productivity. For example, DFAS uses a centralized management approach and reports that its SPI program has helped decrease development costs to about one-third lower than those of similar organizations. In contrast, the Army uses a decentralized approach and also reports that the SPI program for one of its organizational units has helped it almost double its productivity in developing software.

DOD-wide activities to promote and leverage component SPI programs do not exist. According to the IDEAL[SM] model, leveraging SPI experiences is fundamental to continuous process improvement. While two organizational units within the Office of the Secretary of Defense (OSD) that have important leadership roles to play in department software and system processes are both taking steps aimed at strengthening DOD software, these steps do not specifically include SPI. In particular, OSD does not have initiatives under way or planned to determine where in DOD SPI programs do and do not exist so that steps can be taken to promote programs in component units where they do not, such as at DLA. Similarly, actions do not exist to share information across the department about the experiences of successful SPI programs, such as those within the Army, Navy, Air Force, and DFAS. According to OSD officials, uncertainty about the costs versus

benefits of SPI, resource constraints, and other priorities have precluded such a focus. Without such actions, DOD is missing opportunities to realize potential SPI benefits in all DOD components. To address this, we are making recommendations to the Secretary of Defense.

DOD provided written comments on a draft of this report. In commenting, DOD agreed that SPI practices should be used and encouraged and that information about best practices should be shared. However, DOD stated that it is premature at this point to mandate SPI programs throughout the department, as we recommend, and that it has established a working group to review how best to proceed. While we believe that sufficient bases currently exist to mandate SPI, particularly in light of the evidence in this report on (1) components that are not implementing SPI in the absence of a mandate and (2) the benefits being reported by components that are implementing SPI, we do not view DOD's desire to await the results of its working group as being unreasonable or inconsistent with our recommendations.

Components' SPI Program Alignment With SEI IDEAL^{SM} Model Varies

The Army and Air Force units that we reviewed, as well as DFAS and two of the four Navy units, have long-standing SPI programs that satisfy almost every task recommended in the IDEAL^{SM} model (see table 1 for a summary of how each component and its units, if applicable, compared to the model). For example, in 1996 the Secretary of the Army mandated that all software development, acquisition, and maintenance activities establish SPI programs. Further, the Army requires that its software activities continually improve their process maturity and has set maturity goals for all of its units. Army regulations also mandate that contractors be evaluated for software process maturity. Moreover, the two specific units within the Army that we reviewed have SPI management structures, plans, and dedicated resources. In addition, these units have continuously evolved in software and system process maturity through many years of assessing their baseline process capabilities, implementing new and improved process initiatives, reassessing process maturity, and implementing lessons learned. Both Army units satisfy all IDEAL^{SM} tasks.

Table 1: Comparison of Components With IDEAL[SM] Model

Component	Command/major organizational unit	Software/systems unit	Generally satisfied?
Army	Communications-Electronics Command	Software Engineering Center, Fort Monmouth, NJ	Yes
	Aviation and Missile Command	Software Engineering Directorate, Redstone Arsenal, AL	Yes
Navy	Naval Aviation Systems Command, Patuxent River, MD	Not applicable[a]	Yes
	Space and Naval Warfare Systems Command	Systems Center	
		San Diego, CA	Yes
		Chesapeake, VA	No
		Charleston, SC	No
Air Force	Electronic Systems Center	Standard Systems Group, Maxwell Air Force Base, AL	Yes
		Materiel Systems Group, Wright-Patterson Air Force Base, OH	Yes
	Air Force Academy, Colorado Springs, CO	Not applicable	Yes
Marine Corps	Marine Corps Systems Command	Marine Corps Tactical Systems Support Activity, Camp Pendleton, CA	No
DFAS	Information and Technology Directorate, Arlington, VA	Not applicable	Yes
DLA	Headquarters, Fort Belvoir, VA	Not applicable	No

[a]Not applicable indicates that SPI responsibility resides with the "Command/major organizational unit" and not with a "Software/systems unit."

In contrast, DLA, the Marine Corps, and two of the Navy's four units that we reviewed do not perform important IDEAL[SM] model tasks. In particular, DLA currently does not satisfy any of the model's recommended tasks. According to DLA officials, it had an SPI program prior to 1998, but at that time the program was terminated to reduce costs. During our review, DLA's CIO stated that the agency plans to begin a new SPI program and has taken a first step by assigning organizational responsibility.

The Marine Corps has many SPI activities under way that could form the foundation of a program. However, it is not performing several key SPI tasks that are fundamental to SPI program success. For example, the Marine Corps has assigned responsibility for process improvement, and it has begun assessing its software process maturity to establish baseline

capability. However, it is not using this baseline as a basis for implementing recommended improvements, nor does it have an SPI plan or dedicated resources for these activities. As such, the likelihood of the Marine Corps' process improvement initiatives producing desired results is diminished.

Two of the four Navy software/systems units that we reviewed also do not have SPI programs that are aligned with the IDEAL[SM] model. To their credit, however, one has recently taken the first step toward initiating a program and the other has activities under way that could form the beginnings of a program. (See appendix IV for more detailed results on each of the components that we reviewed.)

Components' SPI Management Approaches Vary, Yet All Report Positive Program Results

The four components that have SPI programs—Army, Air Force, DFAS, and parts of the Navy—have different approaches for directing and controlling their respective programs, ranging from centralized to highly decentralized; each, however, reports positive results. For example, DFAS has a centralized approach, with its headquarters office directing and controlling all SPI activities. In contrast, the Army, Air Force, and Navy have decentralized approaches to SPI program management. The Army, which began its SPI program centrally, has since delegated SPI responsibility to its commands, which—in the case of the two commands we reviewed—have further delegated SPI program management to their respective software/systems units. Similarly, the Air Force units that we reviewed further delegated SPI management to their respective software/systems units. The Navy commands follow different approaches—one manages its program centrally and the other has delegated SPI management to its software/systems units.

Despite different approaches, each DOD component/unit with an SPI program reports positive effects on software/systems quality. DFAS, for example, reports that its SPI program has reduced its cost to deliver software to about one-third less than organizations of similar size. One Navy software activity reports reduced costs, improved product quality, and a 7:1 return on its SPI investment. An Army activity reports that it has almost doubled its productivity in writing software for new systems because of improvements made under its SPI program. (See appendix IV for more detailed information on the approaches and reported benefits of the components that we reviewed.)

DOD-Wide Efforts to Promote and Leverage SPI Programs Do Not Exist

Within OSD, the Assistant Secretary for Command, Control, Communications, and Intelligence is responsible for establishing and implementing DOD's policies, processes, programs, and standards governing the development, acquisition, and operation of nonweapons systems software and information systems.[10] Similarly, the Under Secretary for Acquisition, Technology, and Logistics is responsible for establishing DOD acquisition policies and procedures.[11] Accordingly, OSD has an important leadership role to play in ensuring that DOD components reap the maximum possible benefits of effective SPI programs. Such leadership can include dissemination of policies and guidance promoting SPI programs and activities, knowledge of the nature and extent of components' SPI programs and activities, associated lessons learned and best practices, and facilitation of SPI knowledge-sharing across DOD components.

Both OSD organizational units have efforts under way aimed at improving some aspects of DOD's ability to develop and acquire software and systems. For example, they have established teams to conduct software acquisition maturity assessments and established a software collaborators group. They also are collecting software metrics and establishing training for managers.

However, OSD has no SPI actions under way or planned, such as issuing policy and guidance on SPI programs; determining where in DOD SPI programs do and do not exist; promoting the establishment of programs in component units, such as DLA, where they do not exist; and sharing knowledge across DOD about the experiences of reportedly successful SPI programs, such as those within the Army, Air Force, DFAS, and parts of the Navy. According to OSD officials, uncertainty about the costs versus benefits of SPI, resource constraints, and other priorities have precluded such a focus. However, as stated earlier in this report, various organizations, including some DOD components, report positive returns on investments from SPI programs that argue for SPI being treated as a funding priority.

[10]DOD Directive 5137.1.

[11]DOD Directive 5134.1.

Conclusions

Several DOD components have SPI programs that are aligned closely to the best practices embodied in the SEI IDEAL[SM] model and thus provide excellent examples of SPI. However, such programs are lacking in other parts of the department. Where they exist, these programs are being credited with producing higher quality software and systems products faster and at less expense, whether managed in a centralized or decentralized fashion.

OSD has an important leadership role to play in expanding SPI across the department. In particular, it can seize opportunities to build upon and leverage the existing base of SPI programs within DOD's components and help ensure that all of its components realize the strategic value (i.e., benefits that exceed costs) that both private and public-sector organizations, including some DOD components, attribute to these programs. While OSD is faced with making funding choices among competing leadership initiatives, such as its efforts to conduct software acquisition maturity assessments and collect software metrics, these are some of the very tasks that are embedded within an effective SPI program. Thus, by ensuring that DOD components have effective SPI programs, OSD can leverage programs to indirectly accomplish its other high-priority initiatives as well.

Recommendations for Executive Action

To strengthen DLA, Marine Corps, and Navy software and systems development, acquisition, and engineering processes, we recommend that the Secretary of Defense direct the Director of DLA, the Commandant of the Marine Corps, and the Secretary of the Navy to establish SPI programs where this report shows none currently exist. In so doing, these officials should consider following the best practices embodied in the SEI IDEAL[SM] model and drawing from the experiences of the Army, Air Force, DFAS, and some Navy units.

Further, to strengthen DOD-wide SPI, we recommend that the Secretary of Defense direct the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence, in collaboration with the Under Secretary of Defense for Acquisition, Technology, and Logistics, to (1) issue a policy requiring DOD components that are responsible for systems/software development, acquisition, or engineering to implement SPI programs, and (2) develop and issue SPI guidance and, in doing so, consider basing this guidance on the SEI IDEAL[SM] model and the positive

examples of SPI within the Army, Air Force, DFAS, and some Navy units cited in this report.

We also recommend that the Secretary direct the Assistant Secretary for Command, Control, Communications, and Intelligence to (1) annually determine the components' compliance with the SPI policy and (2) establish and promote a means for sharing SPI lessons learned and best practices knowledge throughout DOD.

Agency Comments and Our Evaluation

In written comments on a draft of this report, the Deputy Assistant Secretary of Defense for Command, Control, Communications, and Intelligence, who is also the DOD Deputy Chief Information Officer (CIO), agreed with the report's message that SPI practices should be used and encouraged, and that information about SPI practices should be shared among DOD components. To this end, and since receiving a draft of this report, the Deputy CIO stated that the Under Secretary of Defense (Acquisition, Technology, and Logistics) has established a working group[12] that is, among other things, to develop a plan for implementing SPI. According to the Deputy CIO, this plan will be ready for internal review in April 2001.

Further, the Deputy CIO stated that a January 2001 revision to DOD Regulation 5000.2-R[13] represents a policy step toward addressing software improvement by including in the regulation a section on software management. According to the Deputy CIO, while this section does not specifically call for an SPI program, the regulation provides guidance for improving software by using, for example, SEI's Capability Maturity Model level 3 or its equivalent for major acquisition programs with procurement costs in excess of $2.19 billion.[14]

[12]This group is called the Independent Expert Program Review Working Group. It was established in January 2001.

[13]Interim Regulation 5000.2-R, "Mandatory Procedures for Major Defense Acquisition Programs and Major Automated Information System Acquisition Programs" (January 4, 2001).

[14]Interim Regulation 5000.2-R refers to these programs as Acquisition Category (ACAT) 1 programs.

In light of the above, the Deputy CIO stated that DOD agreed with our recommendation to establish and promote a means for sharing SPI lessons learned and best practices knowledge throughout DOD, and added that a DOD steering group,[15] which was chartered during the course of our review, has been assigned responsibility for this function. However, the Deputy CIO disagreed with our recommendation that DOD issue a policy to mandate SPI programs for all DOD components and their relevant activities. According to the Deputy CIO, establishing a policy requiring or otherwise directing DOD components that do not have SPI programs to implement them would be premature at this time because there are insufficient data to justify the sole use of the SEI IDEAL^{SM} model and that unless a specific model were used, compliance with such a policy or directive would be problematic. Therefore, the Deputy CIO stated a decision regarding the issuance of DOD-wide policy mandating the implementation of SPI programs would not be made until the work group reports its results and develops its plan for implementing SPI. At this point and without the work group's findings, according to the Deputy CIO, issuance of SPI guidance (as opposed to "policy") would be "a more beneficial approach."

In our view, the Deputy CIO's comments are not inconsistent with our recommendations, and our point of disagreement appears to center around simply the timing of actions rather than the recommended actions themselves. Specifically, while we continue to believe that sufficient bases currently exist for issuance of a DOD SPI policy requirement, especially in light of the evidence in our report that (1) without this requirement not all components are implementing SPI and (2) those components that are currently implementing SPI are reporting substantial benefits, it is reasonable for DOD to await its work group's results before making a decision on how to proceed. Further, we agree with the Deputy CIO's comment that there are insufficient data to justify citing in DOD policy the SEI IDEAL^{SM} model as the single model for SPI. Our report recognizes that not all of the DOD components that we cited as having effective SPI programs are using the same model. As a result, our recommendations did not prescribe a specific SPI model. Instead, we recommended that in developing SPI policy and associated guidance, DOD should consider basing this guidance on the SEI IDEAL^{SM} model as well as the positive

[15]This group is called the Software Intensive Systems Steering Group. It was chartered in September 2000.

examples of SPI within the Army, Air Force, DFAS, and some Navy units cited in the report.

Regarding the Deputy CIO's comment that DOD has recently revised DOD Regulation 5000.2-R to include guidance for improving software management through the use of, for example, SEI's Capability Maturity Model level 3, we note that level 3 requirements include performance of process improvement practices that are expanded upon by the SEI IDEAL[SM] model. Additionally, we note that the regulation does not apply to all DOD software/system programs but, rather, only to acquisition programs that exceed a certain dollar threshold. Therefore, the revised regulation does not fulfill the intent of our recommendations.

DOD's written comments, along with our responses, are reproduced in appendix II.

We are sending copies of this report to Senator John Warner, Senator Carl Levin, Senator Ted Stevens, Senator Daniel Inouye, and to Representative Bob Stump, Representative Ike Skelton, and Representative C.W. Bill Young, in their capacities as Chairmen, Ranking Members, or Ranking Minority Members of Senate and House Committees and Subcommittees. In addition, we are sending copies of this report to the Secretaries of the Army, Navy, and Air Force; the Commandant of the Marine Corps; the Directors of DLA and DFAS; and the Director, Office of Management and Budget. Copies will also be available at GAO's web site, *www.gao.gov*.

If you have any questions about this report, please contact me at (202) 512-3439 or by e-mail at *hiter@gao.gov*. Key contributors to this report are listed in appendix V.

Randolph C. Hite
Director, Information Technology Systems Issues

Objectives, Scope, and Methodology

Our objectives were to (1) compare selected DOD components' SPI programs against SEI's IDEAL[SM] model, which is a recognized best practices model; (2) determine how these components have approached management of their SPI programs and what program results they are reporting; and (3) determine what DOD-wide efforts are under way to promote and leverage the components' SPI programs. The selected components include all four services—Army, Air Force, Navy, Marine Corps—and two DOD agencies that have large, software-intensive system modernization programs under way—the Defense Finance and Accounting Service (DFAS) and the Defense Logistics Agency (DLA).[1]

To address the first objective, we reviewed the components' respective information technology strategic plans as well as available SPI policies, guidance, and program documentation, and interviewed headquarters officials from each component. Using this information, we first ascertained whether SPI programs or activities existed for a component, and if so, how they were organized and structured. For the components in which we found SPI programs or activities, we then identified the units within the components responsible for implementing those programs and activities. In instances in which these responsibilities were decentralized (Army, Air Force, and Navy), we worked with component headquarters and command officials to select at least two units in each component that collectively (1) had missions involving both software-intensive weapons and business systems and (2) were responsible for the largest percentages of software and systems development, acquisition, and engineering activities within each component. Table 2 shows the DOD components and software/systems units where we reviewed SPI programs and activities. Where "not applicable" is indicated in the table, SPI responsibility resided at the "Command/major organizational unit," and therefore our work did not extend to a "Software/systems unit."

[1]DFAS plans to spend over $2.2 billion by 2007 to modernize its finance and accounting systems. DLA plans to spend about $525 million by 2005 to modernize its business systems.

Table 2: Software/Systems Units Selected for Review

Component	Command/major organizational unit	Software/systems unit
Army	Communications-Electronics Command	Software Engineering Center
	Aviation and Missile Command	Software Engineering Directorate
Navy	Naval Aviation Systems Command	Not applicable
	Space and Naval Warfare Systems Command	Systems Center San Diego Chesapeake Charleston
Air Force	Electronic Systems Center	Standard Systems Group Materiel Systems Group
	Air Force Academy	Not applicable
Marine Corps	Marine Corps Systems Command	Marine Corps Tactical Systems Support Activity
DFAS	Information and Technology Directorate	Not applicable
DLA	Headquarters	Not applicable

For each unit that we identified as being responsible for implementing an SPI program or activities, we analyzed relevant SPI program documentation, including program descriptions, plans, budgets, and progress and performance measures and reports, and interviewed program officials. We then compared this information with the SPI tasks specified and described in SEI's IDEAL^{SM} model to determine whether the program satisfied the model.

Designed to assist organizations in implementing and managing effective SPI programs, the SEI-developed IDEAL^{SM} model comprises five specific phases; a sixth element addresses overall management of the five phases. Table 3 provides more information about the tasks involved in each phase. Table 4 lists every task included under each phase.

Table 3: Phases of the IDEAL[SM] Model

Phase	Description of typical tasks
Initiating (10 tasks)	Senior managers establish SPI program structure, define roles, allocate resources, and develop a plan to guide the organization through the *Establishing* phase; management commitment and funding are obtained. Two key structural components established in this phase are a management steering group and a software engineering process group (SEPG).
Diagnosing (6 tasks)	SEPG—with line managers and practitioners—appraises the level of software process maturity to obtain a baseline capability against which to measure progress. Any existing process improvement initiatives are identified, along with weaknesses and needed improvement activities.
Establishing (14 tasks)	SEPG, line managers, and practitioners prioritize SPI activities and develop strategies and an action plan, including measurable goals and metrics for monitoring progress. Resources needed to implement the plan are committed, and training is provided for technical working groups that will develop and test new or improved processes.
Acting (10 tasks)	Pilot tests are planned and executed to evaluate new and improved processes created by the technical working groups. If tests succeed, plans are developed for organizationwide adoption, institutionalization, and execution.
Leveraging (7 tasks)	Senior managers assess and apply lessons learned to enhance the SPI program's structure and plans.
Managing (6 tasks)	Senior managers ensure that decisions made are based on organizational needs and that the management structure guides and prioritizes SPI tasks.

Table 4: Phases and Tasks of the IDEAL[SM] Model

Phase	Task
Initiating	Organize discovery team to develop a proposal to management for launching SPI program
	Identify business needs and drivers for improvement
	Build an SPI proposal
	Educate and build support
	Obtain approval for SPI proposal and initial resources
	Establish SPI infrastructure
	Assess the climate for SPI
	Define general SPI goals
	Define guiding principles of SPI program
	Launch the program

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Phase	Task
Diagnosing	Determine what baseline(s) are needed
	Plan for baseline(s)
	Conduct baseline(s)
	Present findings
	Develop final findings and recommendations report
	Communicate findings and recommendations to organization
Establishing	Select and get training in a strategic planning process
	Review organization's vision
	Review organization's business plan
	Determine key business issues
	Review past improvement efforts
	Describe motivations to improve
	Identify current and future (planned) improvement efforts
	Finalize roles and responsibilities of infrastructure entities
	Prioritize activities and develop improvement agenda
	Reconcile existing planned improvement efforts with baseline findings and recommendations
	Transform general SPI goals to measurable goals
	Create/update SPI strategic plan
	Build consensus, review, approve SPI strategic plan and commit resources
	Form technical working group
Acting	Complete tactical plan for technical working group
	Develop solutions
	Pilot potential solutions
	Select solution providers
	Determine long-term support needs
	Develop rollout strategy and plan template
	Package improvement and turn over to SEPG
	Disband technical working group
	Roll out solution
	Transition to long-term support
Leveraging	Gather lessons learned
	Analyze lessons learned
	Revise organizational approach
	Review sponsorship and commitment
	Establish high-level goals
	Develop new/revised SPI proposal

(Continued From Previous Page)

Phase	Task
	Continue with SPI
Managing	Set the stage for SPI
	Organize the SPI program
	Plan the SPI program
	Staff the SPI program
	Monitor the SPI program
	Direct the SPI Program

To address the second objective, we analyzed the aforementioned information, conducted additional interviews, and reviewed additional program information from the component units to which SPI management responsibility had been delegated. As part of this objective, we also reviewed program progress and performance reports and discussed program accomplishments with responsible officials to identify examples of SPI benefits. We then analyzed each component's SPI program results in relation to its program management approach to determine whether any patterns were evident. We did not independently validate components' reported accomplishments and benefits.

To address the third objective, we interviewed responsible component officials, reviewed supporting records and documentation, and visited Internet sites to identify SPI program best practices and lessons learned, along with what efforts are being made to share these with other activities and components throughout the department. We also identified two offices within the Office of the Secretary of Defense (OSD) that have responsibility and activities underway relating to the advancement of software and system management practices in the department—the Office of the Deputy Under Secretary of Defense for Acquisition, Technology, and Logistics; and the Office of the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence. For each office, we analyzed documentation describing their respective ongoing and planned activities and interviewed officials. In doing so, we focused on identifying any activities that specifically promoted and leveraged SPI programs and activities under way throughout DOD. We also discussed with SPI program officials in each component their awareness of the OSD efforts.

We performed our work at Army headquarters, the Pentagon, Arlington, Virginia; and interviewed officials and reviewed documentation from the Communications-Electronics Command Software Engineering Center at Fort Monmouth, New Jersey; and the Aviation and Missile Command

Software Engineering Directorate at Redstone Arsenal, Alabama. We also performed our work at Navy headquarters in Arlington, Virginia; and interviewed officials and reviewed documentation from the Naval Aviation Systems Command at Patuxent River, Maryland; and the Space and Naval Warfare Systems Command Centers at San Diego, California; Chesapeake, Virginia; and Charleston, South Carolina. We also interviewed officials and reviewed documentation from the Air Force's Electronic Systems Center Standard Systems Group at Maxwell Air Force Base, Alabama; the Materiel Systems Group at Wright-Patterson Air Force Base, Ohio; and the Air Force Academy in Colorado Springs, Colorado. We also performed our work at Marine Corps headquarters in Arlington, Virginia; and interviewed officials and reviewed documentation from the Marine Corps Systems Command in Quantico, Virginia; and the Marine Corps Tactical Systems Support Activity at Camp Pendleton, California. We also performed work at DFAS headquarters in Arlington, Virginia; and DLA headquarters at Fort Belvoir, Virginia. We conducted our work from March through December 2000, in accordance with generally accepted government auditing standards.

Comments From the Department of Defense

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
6000 DEFENSE PENTAGON
WASHINGTON, DC 20301-6000
March 2, 2001

COMMAND, CONTROL, COMMUNICATIONS, AND INTELLIGENCE

Mr. Joel C. Willemssen
Managing Director
Information Technology Issues
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Willemssen:

Thank you for the opportunity to review the GAO Draft Report, "DoD INFORMATION TECHNOLOGY: Software and System Process Improvement Programs Vary in Use of Best Practices," January 4, 2001 (GAO code 511686/OSD Case 3026). After careful review, we partially concur with the recommendations presented in the report.

We agree that software process improvement (SPI) practices should be used, encouraged, and information shared. However, it is premature to issue a DoD-wide policy mandating the implementation of a SPI program until the results are received from the Independent Expert Program Review Working Group (IEPRWG).

The IEPR WG, established by the Under Secretary of Defense (Acquisition, Technology, and Logistics), will develop an implementation plan that will directly address software process improvement. This plan will be ready for internal review in April 2001.

The Department has taken other steps in policy to address software improvements. DoD Regulation 5000.2-R has been revised to include a section on software management. Although this section does not specify a software process improvement program, it does provide guidance for improving software such as the implementation of the Software Engineering Institute's Capability Maturity Model Level 3, or its equivalent for ACAT 1 programs.

Specific comments on the Report and its recommendations are provided, along with the software management additions to 5000.2-R, in the enclosure.

Sincerely,

Paul R. Brubaker
Deputy Assistant Secretary of Defense
Deputy Chief Information Officer

Enclosure

GAO DRAFT REPORT – DATED JANUARY 4, 2001
GAO CODE 511686/OSD CASE 3026

"DOD INFORMATION TECHNOLOGY: Software and Systems Process Improvement Programs Vary in Use of Best Practices"

DEPARTMENT OF DEFENSE COMMENTS TO THE RECOMMENDATIONS

RECOMMENDATION 1: The GAO recommended that the Secretary of Defense direct the Director of DLA, the Commandant of the Marine Corps, and the Secretary of the Navy to establish SPI programs where this report shows none currently exist. In so doing, these officials should consider following the best practices embodied in the SEI IDEAL^{SM} model and drawing from the experience of the Army, Air Force, DFAS and some Navy units. (p. 13/Draft Report)

See comment 1.

DoD RESPONSE: Non-concur. A more beneficial approach would be for the Assistant Secretary of Defense for Command, Control, Communications and Intelligence, in collaboration with the Under Secretary of Defense for Acquisition, Technology and Logistics to issue DoD guidance for a Software Process Improvement best practice to be adopted DoD-wide. The issuance of a formal policy would create a problem in determining compliance unless a specific SPI model was recommended. Currently there is insufficient data for the justification of use of a single SPI model to be cited in formal DoD-wide policy.

The Independent Expert Program Review Working Group (IEPR WG), established by the Under Secretary of Defense (Acquisition, Technology, and Logistics), will develop an implementation plan that will influence software process improvement. This plan will be ready for internal review in April 2001.

OSD is developing a set of measures to indicate causes of program cost, schedule and performance deficiencies related to software management. These measures are based upon higher level goals and are analogous to the initial phases of the IDEAL^{SM} model. The measures, once implemented, will begin to assess software process improvement efforts.

RECOMMENDATION 2: The GAO recommended that the Secretary of Defense direct the Assistant Secretary of Defense for Command, Control, Communications and Intelligence, in collaboration with the Under Secretary of Defense for Acquisition, Technology, and Logistics to (1) issue a policy requiring DoD components that are responsible for systems/software development, acquisition, or engineering to implement SPI programs, and (2) develop and issue SPI guidance, and in doing so, consider basing this guidance on the SEI IDEAL^{SM} model and the positive examples of SPI within the Army, Air Force, DFAS, and some Navy units cited in this report. (p. 13/Draft Report)

See comment 2.

DoD RESPONSE: Non-concur. It is premature to issue a DoD-wide policy mandating the implementation of a SPI program until the results are received from the IEPR WG.

RECOMMENDATION 3: The GAO recommended that the Secretary direct the Assistant Secretary of Defense for Command, Control, Communications and Intelligence to (1) annually determine the Components' compliance with the SPI policy; and (2) establish and promote a means for sharing SPI lessons learned and best practices knowledge throughout DoD. (p. 13/Draft Report)

See comment 3.

DoD RESPONSE: Partially concur. The Assistant Secretary of Defense for Command, Control, Communications and Intelligence should not annually determine the components' compliance with the SPI policy for the reason stated above. There would be significant difficulty in establishing a baseline measure to determine compliance with any SPI policy or practice without requiring the implementation of a specific model.

We concur that SPI lessons learned and best practices should be promoted throughout DoD and this is one of the functions of the Software Intensive Systems Steering Group (SIS SG) (charter attached). This SIS SG contains members from each Service and C3I, and is chaired by the Deputy Under Secretary of Defense for Science and Technology.

General C3I Comment

Software management sections have been added to DoD Regulation 5000.2-R "Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs" that have bearing on SPI. This is the first major policy statement to specifically address software management that promotes a DoD-wide SPI program. Section 5.2.6, et. seq. of the DoD 5000.2-R Regulation are provided below:

5.2.6 Software Management
The PM shall manage and engineer software-intensive systems using best processes and practices known to reduce cost, schedule, and performance risks.

5.2.6.1 General
The PM shall base software systems design and development on systems engineering principles, to include the following:

- Develop architectural based software systems that support open system concepts; exploit COTS computer systems products; and allow incremental improvements based on modular, reusable, extensible software;
- Identify and exploit, where practicable, government and commercial software reuse opportunities before developing new software;
- Select the programming language in context of the systems and software engineering factors that influence overall life-cycle costs, risks, and the potential for interoperability;
- Use DoD standard data and follow data administrative policies in *DoDD 8320.1*[1];
- Select contractors with domain experience in developing comparable software systems; with successful past performance; and with a mature software development capability and process. Contractors performing software development or upgrade(s) for use in an ACAT I program shall undergo an evaluation, using either the tools developed by the Software Engineering Institute (SEI), or those approved by the DoD Components and the Deputy Under Secretary of Defense (Science and Technology) (DUSD(S&T)). At a minimum, full compliance with SEI Capability Maturity Model Level 3, or its equivalent in an approved evaluation tool, is the Department's goal. However, if the prospective contractor does not meet full compliance, a risk mitigation plan and schedule shall be prepared to describe, in detail, actions that will be taken to remove deficiencies uncovered in the evaluation process. The risk mitigation plan shall require PM approval. The DUSD(S&T) shall define Level 3 equivalence for approved evaluation tools. The evaluation shall examine the business unit proposed to perform the work. Evaluation results shall remain valid for a period of 2 years.
- Use a software measurement process in planning and tracking the software program, and to assess and improve the software development process and the associated software product. Provide those measures to the appropriate

OSD oversight office. For example, Major Automated Information System PMs shall follow the process described in the Practical Software and System Measurement Guidebook (http://www.psmsc.com/).

- Assess information operations risks (*DoDD S-3600.1*[II]) using techniques such as independent expert reviews;
- Prepare for life-cycle software support or maintenance by developing or acquiring the necessary documentation, host systems, test beds, and computer-aided software engineering tools consistent with planned support concepts; and by planning for transition of fielded software to the support/maintenance activity;
- Track COTS software purchases and maintenance licenses; and
- Structure a software development process that recognizes that emerging requirements will require modification to software over the life cycle of the system. In order to deliver truly state-of-the-software, this process should allow for periodic software enhancements.

5.2.6.2 Software Spiral Development

When acquiring software for a system, the PM shall plan a spiral development process for both evolutionary and single-step-to-full-capability acquisition strategies. A cyclical, iterative build-test-fix-test-deploy process characterizes spiral development and yields continuous improvements in software. Each software release draws upon the experience and lessons of previous releases. The spiral development process shall accomplish the following:

- Facilitate requirements changes resulting from operational mission needs, technology opportunities, experimentation results, and technology obsolescence.
- Incorporate T&E of operational effectiveness, suitability, and supportability using experimentation, demonstration, rigorous testing, or certification.
    - The T&E process shall be continuous throughout the system life cycle and involve the user, contractor, program office, and test community.
    - The T&E process shall consider the near continuous nature of change in the baseline and use techniques such as regression testing to ensure that existing functionality has not been compromised.
    - The PM shall consider the risks and extent of change impacts to enable a cost-effective, yet rigorous T&E process.
- Implement configuration, change, and data management.
    - Documented actual deployed capability provides the starting point for development of the next improvement release and provides a baseline for verification, training, etc.
    - The PM shall implement a configuration control board (CCB) to include the user, program office, development contractor, integration contractor or agency, and any other critical stakeholder.
    - For legacy systems, the CCB shall include the appropriate support and sustainment organizations.

5.2.6.3 Review of Software-Intensive Programs
An independent expert review team shall review programs and report on technology and development risk, cost, schedule, design, development, project management processes and the application of systems and software engineering best practices. The team shall report their findings directly to the PM and the PEO or equivalent management official. The Deputy Under Secretary of Defense for Science and Technology shall manage the team, composed of a small group of software systems engineering and technology experts.

[i] DoD Directive 8320.1, *DoD Data Administration*, September 26, 1991
[ii] DoD Directive S-3600.1, *Information Operations*, December 9, 1996

THE UNDER SECRETARY OF DEFENSE

3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

21 DEC 2000

MEMORANDUM FOR SERVICE ACQUISITION EXECUTIVES

SUBJECT: Independent Expert Program Reviews of Software Intensive System Acquisitions

The primary recommendation from the recent Defense Science Board study on Defense Software was the institutionalization of Independent Expert Program Reviews (IEPRs) of ACAT I-III software intensive systems. Such reviews are essential to help the Program Manager adequately address issues of cost, schedule, technology, risk and process, and provide an opportunity to share scarce expert resources. They are most effective when performed at a time in the acquisition lifecycle when they can prevent problems, well before a milestone review, rather than react to them. The Software Intensive Systems Steering Group (SISSG), chaired by Deputy Under Secretary of Defense (Science and Technology) (DUSD(S&T)) ah representing the senior software executives from each of the Services and ASD C3I, has enthusiastically endorsed this recommendation.

It is important to implement IEPRs within your Service such that they support your individual programs and integrate with your acquisition processes and organizational responsibilities. It is of equal importance that the results of these reviews contribute to the greater understanding of the risks, problems and best practices across DoD. Therefore, I am asking the DUSD(S&T) to establish an IEPR Working Group (WG) chaired by the Director, Software Intensive Systems. This group will be made up of Service and OSD software acquisition specialists and representatives from assessment organizations throughout DoD. The IEPR WG will develop a plan and necessary policy to implement IEPRs, coordinate IEPR activities, promote IEPR consistency, and coordinate the collection, analysis and distribution of non-attributable IEPR information. The SISSG, as a conduit to the Services' acquisition community, will provide vision and guidance to this group. The DUSD(S&T) will approve the IEPR implementation plan, and forward the plan to my office by April 1, 2001.

Please designate your IEPR WG representatives by January 5, 2001. The point of contact is Dr. Jack Ferguson, Director of Software Intensive Systems, (703) 602-0851, ext. 105.

J. S. Gander

Charter for the DoD Software Intensive Systems Steering Group

1.0 Introduction:

1.1 Purpose of this document. This document establishes the charter for the DoD Software Intensive Systems Steering Group (SISSG). The charter defines the purpose, responsibilities, operation, meeting frequency and membership of the SISSG to oversee activities related to improving the acquisition, development and sustainment of DoD software intensive systems.

1.2 Background. Software in our weapon systems provides not only current functionality but also the flexibility to respond to changing threats and environments for the long lifetimes these systems must endure. For this reason, software is greatly increasing in its percentage of weapon system development cost and schedule. It is estimated that approximately 40% of our $37.6B RDT&E budget is spent on software. However, we consistently endure software development/integration/improvement cost and schedule overruns, with attendant reductions in performance. The Under Secretary of Defense (Acquisition, Technology and Logistics) and the Service Acquisition Executives established the Software Intensive Systems Steering Group to improve the acquisition, development and sustainment of DoD software intensive systems.

2.0 Purpose of the Steering Group:

The purpose of the SISSG is to bring the software engineering capabilities of DoD and the military services to bear on collaborative efforts to improve the development, acquisition, and sustainment of software intensive systems. The SISSG will establish strategic direction, oversee the DoD Software Intensive System effort, and prioritize joint activities that have significant improvement potential.

3.0 SG Responsibilities:

3.1 Establish strategic direction for improvements in software intensive system acquisition, development and sustainment.

3.2 Review, evaluate and oversee implementation and/or response to recommendations of Defense Science Board Task Forces, service advisory boards, and other initiatives related to DoD software and provide expertise for such efforts.

3.3 Identify and prioritize science and technology requirements and opportunities with potential for improving software intensive system acquisition, development, fielding, and sustainment.

3.4 Identify and support opportunities to transition technologies with potential for improving software intensive system acquisition, development, fielding, and sustainment.

3.5 Identify and support opportunities to improve software aspects of Advanced Concept Technology Demonstrations.

3.6 Identify, promote and oversee efforts to improve the abilities of the acquisition workforce to manage software intensive system acquisition.

3.7 Identify, promote and oversee efforts to improve the national software development and sustainment infrastructure, to include information assurance.

4.0 Meeting Frequency:

The SISSG will initially meet monthly, with special meetings held as necessary. Attendance at the SISSG meetings will be by invitation of the SISSG.

5.0 Changes to This Charter:

The charter may be updated based on need. Changes to the charter will be coordinated with DUSD(S&T).

6.0 Membership:

6.1 Steering Group members. The current composition of the SISSG will be as follows:

Organization	*Name*	*Position*
DUSD(S&T)	Delores M. Etter Chair	Deputy Under Secretary of Defense (Science and Technology)
Army	Henry C. Dubin	Director for Assessment and Evaluation, Office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology)
Navy	Michael J. O'Driscoll	Assistant Secretary of the Navy (Research, Development and Acquisition) Deputy Chief Engineer
Air Force	Don Daniel	Deputy Assistant Secretary of the Air Force (Science, Technology and Engineering)
ASD(C3I)	Margaret Myers	Principal Director, DASD (Deputy Chief Information Officer)
DUSD(S&T)/SIS	Jack R. Ferguson Executive Secretary	Director for Software Intensive Systems, ODUSD(S&T)

6.2 The Steering Group will be supported by advisors, such as DARPA (Directors of Information Technology Office and Information Systems Office) and the Director of the Software Engineering Institute.

Software Intensive Systems Steering Group

Delores M. Etter
Delores M. Etter, Chair
DUSD(S&T)
SEP 28 2000
Date

Henry C. Dubin
Army
SEP 28 2000
Date

Michael J. O'Driscoll
Navy
SEP 28 2000
Date

Don Daniel
Air Force
SEP 28 2000
Date

Margaret Myers
ASD(C3I)
28 SEP 2000
Date

The following are GAO's comments on the Department of Defense's letter dated March 2, 2001.

GAO Comments

1. We disagree. Sufficient bases currently exist for issuance of a DOD SPI policy requirement, especially in light of the evidence in our report that (1) without this requirement not all components are implementing SPI and (2) those components that are currently implementing SPI are reporting substantial benefits. Nevertheless, DOD's decision to await an OSD work group's results before making a decision on how to proceed is not unreasonable or inconsistent with our position.

2. See response to comment 1.

3. We disagree. Oversight is an important part of policy implementation, and without such oversight, DOD would incur significant risk that the policy would not be implemented. Further, establishing a baseline measure to determine compliance does not require the implementation of a specific model. The intent of our recommendations is to establish a policy requiring SPI that recognizes, as our report recognizes, that there is more than one model for doing so effectively.

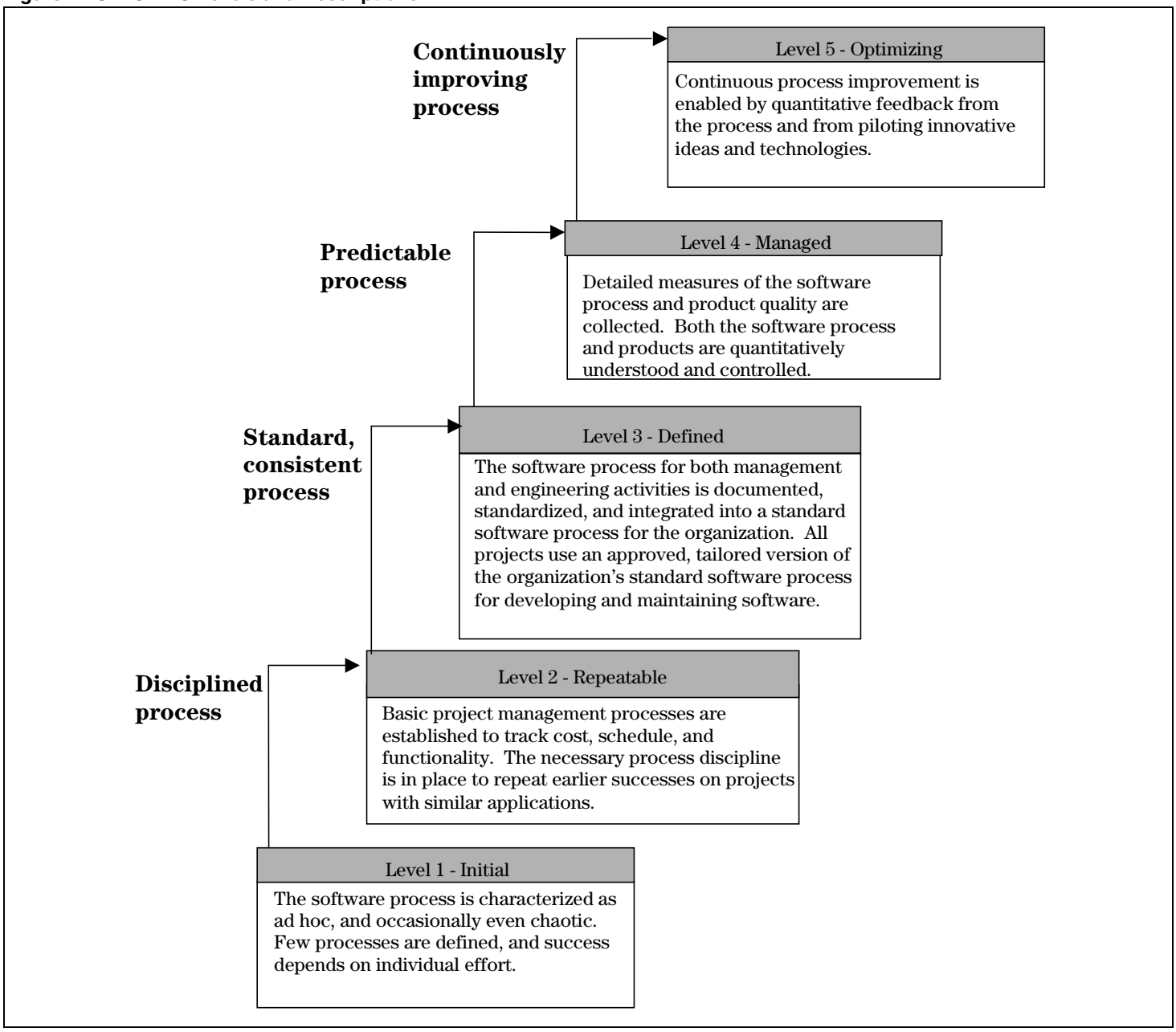
Description of SEI Capability Maturity Models

Since 1984, the Software Engineering Institute (SEI) has worked to improve management of software/systems productivity and quality primarily by addressing problems in acquiring, developing, engineering, or enhancing software/systems through a series of capability maturity models. According to SEI, an organization's process capability provides a means of predicting the most likely outcome of the next software/systems project undertaken; process maturity implies that the productivity and quality resulting from an organization's software/systems processes can be improved as maturity of the processes increases. The IDEAL[SM] model is based on lessons learned from SEI experiences as well as from SEI projects relating to software process capability and maturity. For example, during the initiating phase of the IDEAL[SM] model, general SPI program goals are defined, and this definition could be in terms of capability maturity model levels. In the diagnosing phase, IDEAL[SM] recommends developing an organization process maturity baseline; SEI's capability maturity model–based appraisal is one way of establishing this baseline.

The first of these capability maturity models, the Software Capability Maturity Model® (SW-CMM®),[1] was designed to assist organizations in improving software development and maintenance processes. In this model, software process maturity—ranked from a low of level 1 to a high of level 5—serves as an indicator of the likely range of software cost, schedule, and quality that can be expected to be achieved by projects developed within an organization. (See figure 2.)

[1]Capability Maturity Model and CMM are registered in the U.S. Patent and Trademark Office.

Figure 2: SW-CMM® Levels and Descriptions



Source: SEI.

Since the SW-CMM® was published, SEI has developed additional models in the capability maturity series:

- The Software Acquisition CMM® is a model for improving the software acquisition process. It follows the same five-level architecture as the SW-CMM® but emphasizes acquisition issues and the needs of individuals and groups planning and managing software acquisition activities.
- The Systems Engineering CMM® describes the essential elements of an organization's systems engineering process and provides a reference for comparing actual systems engineering practices against these elements. The model addresses the process aspects of systems engineering and the product development portion of the life cycle. This model was a collaboration of several organizations, including SEI.
- In 1997 a team led by DOD, in conjunction with SEI, government, and industry, concentrated on developing an integrated framework for maturity models and associated products. The result was the CMM Integration℠ (CMMI℠),[2] which is intended to provide guidance for improving an organization's processes and the ability to manage the development, acquisition, and maintenance of products and services, while reducing the redundancy and inconsistency caused by using stand-alone models.

The CMMI℠ combines earlier models from SEI and the Electronic Industries Alliance[3] into a single model for use by organizations pursuing enterprise-wide process improvement. However, the prototype CMMI℠ does not include the acquisition features of the SA-CMM® because the team wanted to focus first on the development process. A CMMI℠ that includes coverage for acquiring software-intensive systems is currently being developed. Additional disciplines may also be covered. Ultimately, the CMMI℠ is to replace the models that have been its starting point.

[2]CMM Integration and CMMI are service marks of Carnegie Mellon University.

[3]The Electronic Industries Alliance is a trade organization representing over 2,000 companies involved in the design, manufacture, and sale of electronic parts, components, assemblies, and systems for residential, commercial, industrial, military, and aerospace use.

Detailed Results of Review of DOD Components' SPI Programs

Army SPI Program

Background

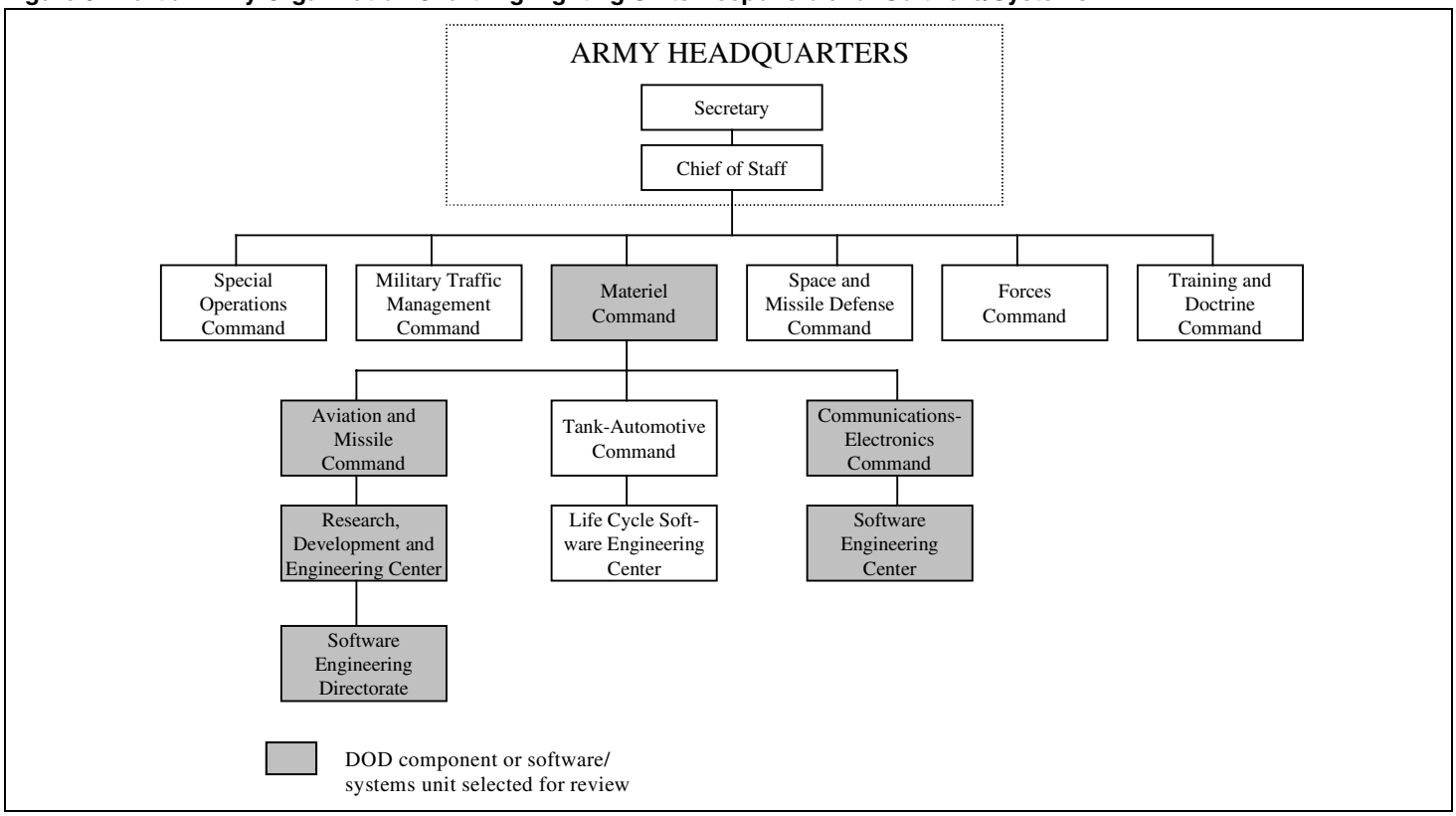
The Army depends on software-intensive systems to support each of its major commands and every facet of its mission, from weapons to financial management systems. The Army budgeted about $3.3 billion on information technology during fiscal year 2000.

The Army has assigned responsibility for information systems to the Army Materiel Command (AMC). Several major subcommands function under AMC. Three of these major subcommands—the Communications-Electronics Command (CECOM), the Aviation and Missile Command (AMCOM), and the Tank-Automotive Command—are responsible for the acquisition, development, engineering, and maintenance of information technology for the Army. We reviewed the Army's SPI activities at CECOM and AMCOM.

CECOM has assigned responsibility for information systems to its Software Engineering Center (SEC). The center, located at Fort Monmouth, New Jersey, is supported by several software/systems activities located across the United States. The center is responsible for overseeing about 85 percent of the Army's systems, including (1) command, control, communications, and computers; (2) intelligence, electronic warfare, and sensors; (3) sustaining base/power projection; and (4) AMC business systems.

AMCOM has assigned responsibility for its information systems to its Software Engineering Directorate (SED). This directorate, located at Redstone Arsenal, Alabama, oversees and provides life-cycle support to both aviation and missile weapons systems. (See figure 3.)

Figure 3: Partial Army Organization Chart Highlighting Units Responsible for Software/Systems



Source: GAO based on Army data.

Army's SPI program activities began in the early 1990s; in mid-1996 the Secretary mandated that all Army software acquisition, development, and maintenance activities establish SPI programs. At the same time, the Army published an SPI policy[1] that specified two requirements:

- First, a contractor's capability to produce quality software will be part of the Army's source-selection evaluation process. The Army has implemented this requirement by evaluating potential contractors against SW-CMM® level 3 maturity requirements and requiring contractors that do not meet these requirements to propose a strategy for mitigating the risks associated with not meeting them. This requirement is further enforced during milestone reviews of major

[1]Army's SPI policy is now part of Army Regulation 70-1.

systems, when the program manager must show that the contractor meets these requirements.

- Second, Army software activities will continually improve their software and systems process maturity, including self-assessments of existing processes, and achieve SW-CMM® level 3 within 6 years of initial assessment.

Army's SPI Program Is Aligned With SEI's IDEAL^{SM} Model

Both the CECOM SEC and the AMCOM SED SPI programs are fully consistent with the IDEAL^{SM} model. Table 5 shows examples of program elements that reflect some of the recommended tasks in the IDEAL^{SM} model; table 6 provides a detailed comparison of CECOM and AMCOM's SPI programs against each of the IDEAL^{SM} model recommended tasks.

Table 5: Army Examples of Alignment With IDEAL^{SM}

Phase/tasks	Task example
Initiating: *Define General SPI goals*	Army issued a 1996 policy that requires all Army software activities to continually improve their software and systems process maturity, including performing self-assessments of existing processes, and achieving SW-CMM® level 3 within 6 years of initial assessment.
Diagnosing: *Determine what baseline(s) are needed*	Both CECOM's SEC and AMCOM's SED have, as part of their continuous process, established SEPGs that are constantly reviewing baselines and making changes as needed.
Establishing: *Create and then update an SPI strategic plan*	Army's latest updated strategic plan, which addresses SPI, was issued in 1997; CECOM has its own strategic plan that also addresses SPI, which was last revised in 1998.
Acting: *Transition to long-term support*	One way to transition to support is to implement policies and handbooks that software activities can use as guidance to improve. CECOM issued software policy in 1996. AMCOM issued a software engineering process handbook and a procedures and standards handbook in 1993; these two publications were combined into one in 1998.
Leveraging: *Gather and analyze lessons learned, and revise the organizational approach, if necessary*	Both CECOM and AMCOM established SEPGs; they gather information on SPI quality at their respective commands and meet weekly to review what they have learned and, if needed, reestablish goals.

Table 6: Comparisons of Army SPI Activities With the IDEAL℠ Model

		Satisfied?	
Phase	**Task**	**AMCOM SED**	**CECOM SEC**
Initiating	Organize discovery team to develop a proposal to management for launching SPI program	Yes	Yes
	Identify business needs and drivers for improvement	Yes	Yes
	Build an SPI proposal	Yes	Yes
	Educate and build support	Yes	Yes
	Obtain approval for SPI proposal and initial resources	Yes	Yes
	Establish SPI infrastructure	Yes	Yes
	Assess the climate for SPI	Yes	Yes
	Define general SPI goals	Yes	Yes
	Define guiding principles of SPI program	Yes	Yes
	Launch the program	Yes	Yes
Diagnosing	Determine what baseline(s) are needed	Yes	Yes
	Plan for baseline(s)	Yes	Yes
	Conduct baseline(s)	Yes	Yes
	Present findings	Yes	Yes
	Develop final findings and recommendations report	Yes	Yes
	Communicate findings and recommendations to organization	Yes	Yes
Establishing	Select and get training in a strategic planning process	Yes	Yes
	Review organization's vision	Yes	Yes
	Review organization's business plan	Yes	Yes
	Determine key business issues	Yes	Yes
	Review past improvement efforts	Yes	Yes
	Describe motivations to improve	Yes	Yes
	Identify current and future (planned) improvement efforts	Yes	Yes
	Finalize roles and responsibilities of infrastructure entities	Yes	Yes
	Prioritize activities and develop improvement agenda	Yes	Yes
	Reconcile existing planned improvement efforts with baseline findings and recommendations	Yes	Yes
	Transform general SPI goals to measurable goals	Yes	Yes
	Create/update SPI strategic plan	Yes	Yes
	Build consensus, review, approve SPI strategic plan and commit resources	Yes	Yes
	Form technical working group	Yes	Yes

(Continued From Previous Page)

		Satisfied?	
Phase	**Task**	**AMCOM SED**	**CECOM SEC**
Acting	Complete tactical plan for technical working group	Yes	Yes
	Develop solutions	Yes	Yes
	Pilot potential solutions	Yes	Yes
	Select solution providers	Yes	Yes
	Determine long-term support needs	Yes	Yes
	Develop rollout strategy and plan template	Yes	Yes
	Package improvement and turn over to SEPG	Yes	Yes
	Disband technical working group	Yes	Yes
	Roll out solution	Yes	Yes
	Transition to long-term support	Yes	Yes
Leveraging	Gather lessons learned	Yes	Yes
	Analyze lessons learned	Yes	Yes
	Revise organizational approach	Yes	Yes
	Review sponsorship and commitment	Yes	Yes
	Establish-high level goals	Yes	Yes
	Develop new/revised SPI proposal	Yes	Yes
	Continue with SPI	Yes	Yes
Managing	Set the stage for SPI	Yes	Yes
	Organize the SPI program	Yes	Yes
	Plan the SPI program	Yes	Yes
	Staff the SPI program	Yes	Yes
	Monitor the SPI program	Yes	Yes
	Direct the SPI program	Yes	Yes

Army Reports That Its Decentralized Approach to SPI Program Management Has Produced Results

When the Army first launched its SPI activities, it managed initiation and diagnosis centrally, with both CECOM and AMCOM being involved in these early actions. Subsequently, as many groups throughout the Army were trained in using the SEI process maturity measurements, responsibility for implementing SPI programs was delegated to the commands. The Army has since expanded this decentralized approach, giving each command the SPI requirements through Army policy and allowing each to implement the policy as it determines best supports its mission.

According to information that these two subcommands provided, their SPI programs have produced positive results. One of AMCOM's measures of software quality is development productivity, which is the number of lines of software code produced as a function of resources invested. According to AMCOM, SED's productivity ratio[2] for new development products increased from 1.30 to 2.48 as a result of moving from SW-CMM® level 2 to level 3. SED reports that it has recently achieved level 4.

Air Force SPI Program

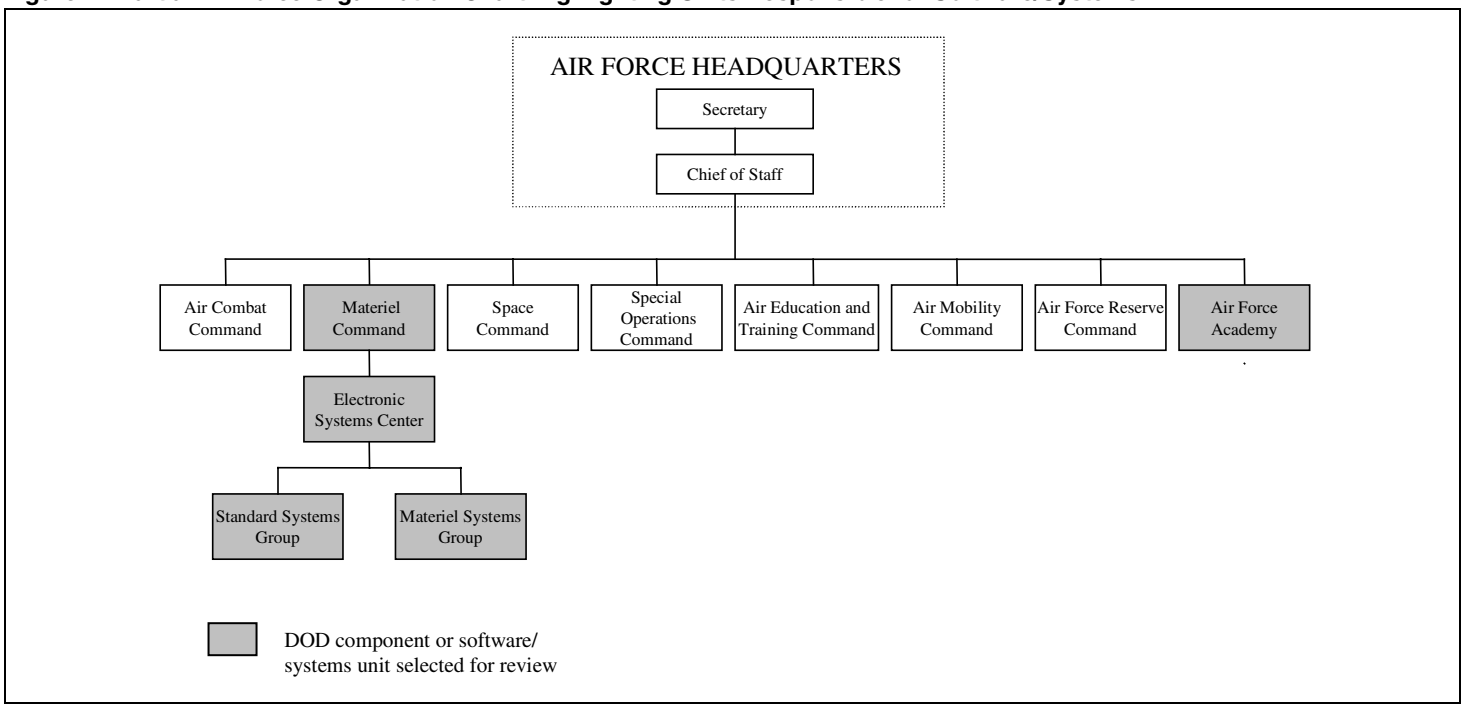
Background

Software-intensive systems are vital to the Air Force's overall mission. They are used to sustain weapons systems, airborne electronics, electronic warfare, space communications, and support equipment. The Air Force has about 1,600 systems and budgeted about $4.6 billion in fiscal year 2000 for information technology.

The Air Force has nine major commands, but its largest software/systems units are under the Air Force Materiel Command (AFMC). Within AFMC, we reviewed SPI efforts at two units within the Electronic Systems Center, which provides command and control and information systems for the Air Force as well as for other DOD units, using a budget of over $3 billion in fiscal year 2000. The two units that we reviewed were the Standard Systems Group (SSG) at Montgomery, Alabama, and the Materiel Systems Group (MSG) at Dayton, Ohio. In addition, we reviewed SPI activities at the Air Force Academy (AFA), which has one of the remaining software/systems units outside AFMC. (See figure 4.)

[2]Productivity equals total software lines of code developed divided by the total effort expended.

Figure 4: Partial Air Force Organization Chart Highlighting Units Responsible for Software/Systems



Source: GAO based on Air Force data.

SSG is the largest software/systems unit within the Air Force in terms of money invested and amount of software delivered. Its mission is to develop and maintain combat support information systems for the Air Force and other DOD components. Additionally, SSG manages information technology contracts and standard information systems programs commonly used at all active and reserve Air Force bases and some DOD agencies worldwide.

Next to SSG, MSG is the largest Air Force central software/systems unit. MSG's mission is to support the Air Force goal of information dominance through acquiring, developing, maintaining, reengineering, and providing technical services for information systems.

AFA has a software/systems unit that is primarily responsible for maintaining and developing the Cadet Administrative Management Information System, a mission-critical database system that tracks the progress of cadets from precandidacy through academic, physical, ethical/moral, and military training programs and, after graduation, throughout their Air Force careers.

In 1991, the Deputy Assistant Secretary of the Air Force initiated the service's SPI program. In particular, Air Force software/systems units were directed to complete SW-CMM® assessments by October 1, 1994, perform follow-up assessments every 2 years, and achieve SW-CMM® level 3 by 1998. Air Force's 1994 SPI policy was revised this year.[3] This revised policy requires all units that develop or maintain software/systems to have an SPI program and a documented SPI plan that includes, at least, a baseline measure of their current capabilities, goals and milestones they intend to reach, and metrics with which to measure their progress toward goals and milestones.

Air Force SPI Program Is Aligned With SEI's IDEAL^{SM} Model

The IDEAL^{SM} model is the framework the Air Force recommends to its software/systems units, and our comparison of the activities at SSG, MSG, and AFA to the IDEAL^{SM} model found that their respective SPI programs are almost all aligned with the model. Specifically, each of the programs satisfied all but five of the IDEAL^{SM} model recommended tasks, and none of those five is significant enough to preclude having effective SPI programs. Table 7 shows examples of the programs' elements that reflect some of the recommended tasks in the IDEAL^{SM} model; table 8 shows a detailed comparison of SSG, MSG, and AFA SPI programs against each of the IDEAL^{SM} model recommended tasks.

Table 7: Air Force Examples of Alignment With IDEAL^{SM}

Phase/tasks	Task example
Initiating: *Establish SPI infrastructure*	In 1993, AFA completed a self-assessment of software engineering processes, identifying key areas for improvement, establishing an SPI program, and assigning responsibility for it.
Diagnosing: *Appraise, characterize, and assess process*	By 1996, all 41 Air Force software units had completed their initial CMM® assessments, 21 systems had conducted a second assessment, and eight were conducting a third assessment.
Establishing: *Strategize, set priorities*	AFMC developed a strategic plan for SSG and MSG, prioritized activities, and provided an improvement agenda.
Acting: *Execute planned improvements*	Based on its experience with a variety of SPI projects, SSG developed and is implementing a standard software development process for all software projects within SSG, regardless of project type.

[3]Air Force Instruction 33-114, July 1, 2000.

(Continued From Previous Page)

Phase/tasks	Task example
Leveraging: *Document and analyze lessons learned, plan changes for next cycle*	SSG shares benchmarking processes with MSG in a strategic partnership; MSG documents lessons learned and enters them into a database.

Table 8: Comparisons of Air Force SPI Activities With the IDEAL℠ Model

		Satisfied?		
Phase	**Task**	**AFA**	**SSG**	**MSG**
Initiating	Organize discovery team to develop a proposal to management for launching SPI program	Yes	Yes	Yes
	Identify business needs and drivers for improvement	Yes	Yes	Yes
	Build an SPI proposal	Yes	Yes	Yes
	Educate and build support	Yes	Yes	Yes
	Obtain approval for SPI proposal and initial resources	Yes	Yes	Yes
	Establish SPI infrastructure	Yes	Yes	Yes
	Assess the climate for SPI	No	No	No
	Define general SPI goals	Yes	Yes	Yes
	Define guiding principles of SPI program	Yes	Yes	Yes
	Launch the program	Yes	Yes	Yes
Diagnosing	Determine what baseline(s) are needed	Yes	Yes	Yes
	Plan for baseline(s)	Yes	Yes	Yes
	Conduct baseline(s)	Yes	Yes	Yes
	Present findings	Yes	Yes	Yes
	Develop final findings and recommendations report	Yes	Yes	Yes
	Communicate findings and recommendations to organization	Yes	Yes	Yes
Establishing	Select and get training in a strategic planning process	Yes	Yes	Yes
	Review organization's vision	Yes	Yes	Yes
	Review organization's business plan	Yes	Yes	Yes
	Determine key business issues	Yes	Yes	Yes
	Review past improvement efforts	Yes	Yes	Yes
	Describe motivations to improve	Yes	Yes	Yes
	Identify current and future (planned) improvement efforts	Yes	Yes	Yes
	Finalize roles and responsibilities of infrastructure entities	Yes	Yes	Yes
	Prioritize activities and develop improvement agenda	Yes	Yes	Yes
	Reconcile existing planned improvement efforts with baseline findings and recommendations	No	No	No
	Transform general SPI goals to measurable goals	Yes	Yes	Yes

Phase	Task	Satisfied?		
		AFA	SSG	MSG
	Create/update SPI strategic plan	Yes	Yes	Yes
	Build consensus, review, approve SPI strategic plan and commit resources	Yes	Yes	Yes
	Form technical working group	Yes	Yes	Yes
Acting	Complete tactical plan for technical working group	Yes	Yes	Yes
	Develop solutions	Yes	Yes	Yes
	Pilot potential solutions	Yes	Yes	Yes
	Select solution providers	Yes	Yes	Yes
	Determine long-term support needs	Yes	Yes	Yes
	Develop rollout strategy and plan template	Yes	Yes	Yes
	Package improvement and turn over to SEPG	Yes	Yes	Yes
	Disband technical working group	No	No	No
	Rollout solution	Yes	Yes	Yes
	Transition to long-term support	No	No	No
Leveraging	Gather lessons learned	Yes	Yes	Yes
	Analyze lessons learned	Yes	Yes	Yes
	Revise organizational approach	Yes	Yes	Yes
	Review sponsorship and commitment	No	No	No
	Establish high-level goals	Yes	Yes	Yes
	Develop new/revised SPI proposal	Yes	Yes	Yes
	Continue with SPI	Yes	Yes	Yes
Managing	Set the stage for SPI	Yes	Yes	Yes
	Organize the SPI program	Yes	Yes	Yes
	Plan the SPI program	Yes	Yes	Yes
	Staff the SPI program	Yes	Yes	Yes
	Monitor the SPI program	Yes	Yes	Yes
	Direct the SPI program	Yes	Yes	Yes

Air Force Reports That Its Decentralized Approach to SPI Program Management Has Produced Results

Air Force headquarters has delegated SPI responsibility to its software/systems units. When the Air Force began its SPI activities in 1991, its goal was to initiate SPI by performing assessments that would indicate the current level of maturity at Air Force units. Management of this effort was centralized in the Air Force Communications Agency (AFCA). AFCA staff visited all 41 Air Force units, some more than once, to perform assessments. Once software/systems units became capable of conducting their own process maturity measurements, Air Force began decentralizing

management of the SPI program to the units. The last year in which the Air Force exercised any centralized management of SPI was 1998.

The Air Force's SPI efforts have been, in its view, beneficial. For example, one Air Force center reported a 7.5-to-1 return on its SPI investment, which was independently verified. An official at another center stated that SPI had allowed its organization to achieve higher process maturity levels and made significant improvements in the quality of its software products and its productivity measures.

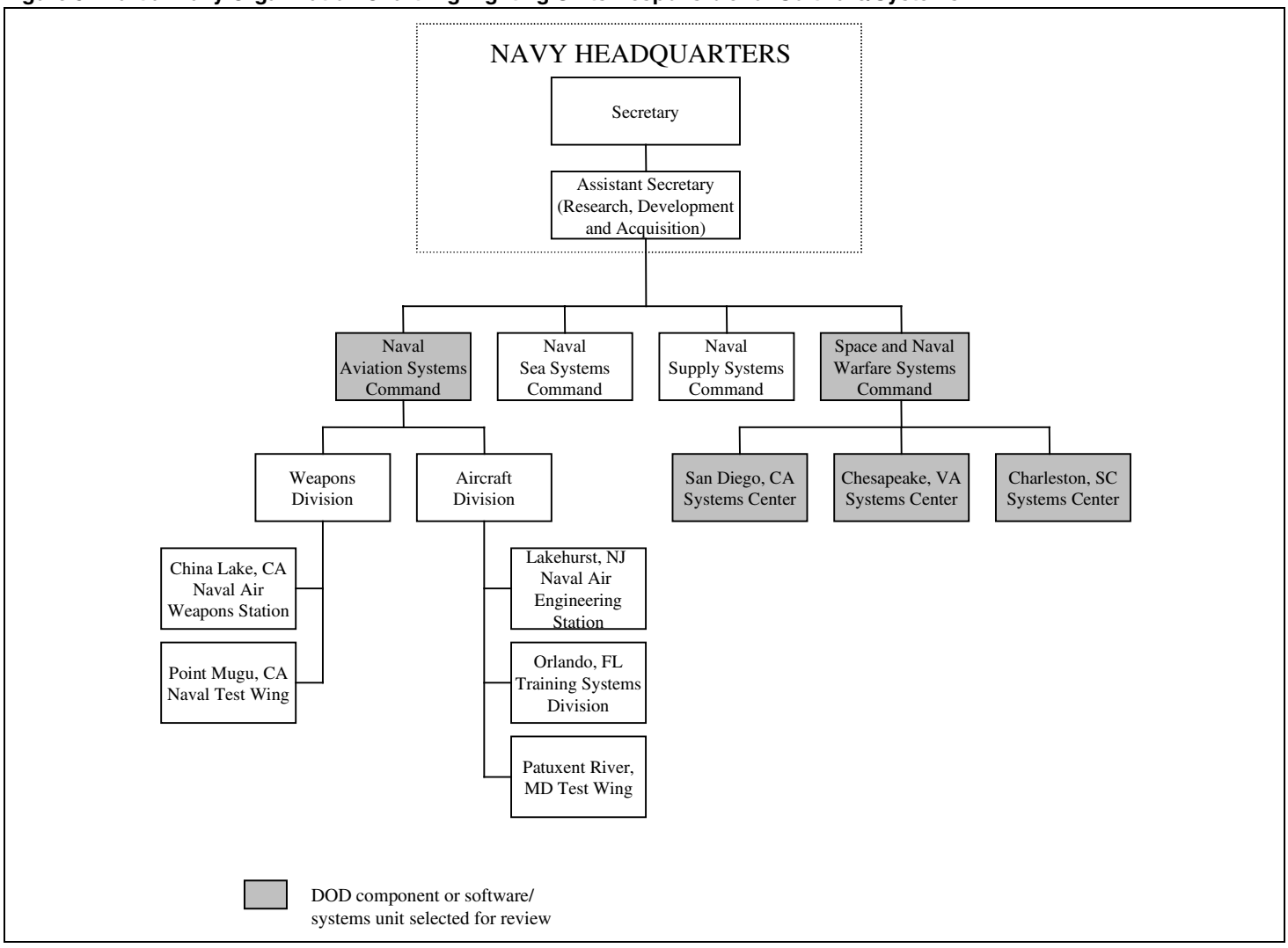
Navy SPI Program

Background

The Navy depends on software-intensive systems to support many functions throughout its nine operating forces—including the Marine Corps—and its 15 support units—including four major systems commands. These systems support some aspect of every operation, including strategic and tactical operations; sophisticated weaponry; intelligence, surveillance, and security; strategic sealift and fleet mobilization and readiness; and routine business functions such as finance, personnel, logistics, and contract management. In fiscal year 2000, the Navy budgeted about $3.1 billion for information technology.

Within the Navy, acquisition, development, and maintenance of these systems is delegated to its major systems commands: the Naval Aviation Systems Command (NAVAIR), Space and Naval Warfare Systems Command (SPAWAR), Naval Sea Systems Command, and Naval Supply Systems Command. We reviewed SPI activities at NAVAIR and SPAWAR. Both commands have several subordinate units involved in acquiring, developing, and maintaining systems. (See figure 5.)

Figure 5: Partial Navy Organization Chart Highlighting Units Responsible for Software/Systems



Source: GAO based on Navy data.

NAVAIR provides full life-cycle support to 148 programs, such as aircraft, avionics, air-launched weapons, electronic warfare, cruise missiles, and unmanned aerial vehicles. NAVAIR has two divisions (weapons and aircraft). The weapons division has two California product centers, and the aircraft division has three centers, located in New Jersey, Maryland, and Florida.

SPAWAR develops, acquires, and maintains systems through three SPAWAR Systems Centers (SSC). These centers are at San Diego, California; Chesapeake, Virginia; and Charleston, South Carolina. We reviewed SPAWAR's SPI efforts at all three centers. SSC San Diego develops, acquires, and supports command, control, communications, and ocean surveillance systems. SSC Chesapeake develops, acquires, and supports supply, inventory, finance, food service, and other information systems. SSC Charleston develops, acquires, and supports command, control, communications, intelligence, surveillance, and reconnaissance systems.

To guide and direct their respective SPI programs, these commands follow DOD and other models and standards.[4] Commands have also established local policy. For instance, SPAWAR policy requires all managers with software-related responsibilities at San Diego to incorporate process improvement in the areas of new development, modification, reuse, reengineering, maintenance, integration, and all other activities resulting in software products. In 2000, NAVAIR published an interim policy that requires prospective contractors to be evaluated at SEI SW-CMM® level 3 for all acquisitions.

Navy's SPI Program Is Partly Aligned With the IDEAL℠ Model

Navy's experience with SPI to date has been mixed. Both SSC San Diego and NAVAIR have SPI programs that are consistent with the IDEAL℠ model. However, SSC Chesapeake's and SSC Charleston's programs are not. Specifically, SSC Chesapeake has only recently initiated an SPI program and, while efforts to date are aligned with the IDEAL℠ model, many important SPI program tasks have yet to be executed. For example, in July 2000 it completed some initiating-phase tasks, such as creating a management steering group and an SEPG. However, it has yet, for example, to (1) conduct baselines to identify process strengths and weaknesses in the diagnosing phase, (2) develop an SPI plan with measurable goals and committed resources in the establishing phase, (3) pilot-test potential solutions or transition the solutions to long-term support in the acting phase, or (4) gather or analyze lessons learned in the leveraging phase.

[4]The Navy uses guidance from DOD Directive 5000.1 and DOD Regulation 5000.2-R, SEI, the DOD Software Program Managers Network's 16 Critical Software Practices, and the Institute of Electrical and Electronics Engineers/Electronic Industries Alliance Standard 12207.

In the case of SSC Charleston, no SPI program exists, although the center has undertaken one task that is intended to begin the initiating phase of a program. Table 9 shows examples of Navy SPI programs' elements that reflect some of the recommended tasks in the IDEAL℠ model; table 10 shows a detailed comparison of NAVAIR and SPAWAR SPI programs against each of the IDEAL℠ model recommended tasks.

Table 9: Examples of Navy Alignment With IDEAL℠

Phase/tasks	Task example
Initiating: *Identify business needs and drivers for improvement*	SSC San Diego identified its key elements for project success in three broad areas—process, people, and technology—by conducting research on process improvement traits of other successful organizations and contracting with SEI to identify program weaknesses and key areas for improvement.
Diagnosing: *Plan for and conduct baseline activities*	SSC San Diego developed a plan for establishing a baseline for all software projects, and all new projects are baselined and assessed before they are implemented.
Establishing: *Finalize roles and responsibilities of infrastructure entities*	NAVAIR's plan for process improvement identifies the general roles and responsibilities in the program. The Software Process Improvement Office has a formal charter that identifies specific roles, goals, and responsibilities.
Acting: *Pilot-test potential solutions*	SSC San Diego pilot-tested 18 SPI projects with over 400 staff from six divisions to raise CMM® maturity levels.
Leveraging: *Analyze lessons learned*	SSC San Diego requires that all projects record lessons-learned data, which are fed into a database that is tracked, reported, and shared across the organization at two levels of best practice—organizational and project.

Table 10: Comparisons of Navy SPI Activities With the IDEAL℠ Model

		Satisfied?			
Phase	**Task**	**NAVAIR**	**SSC San Diego**	**SSC Chesapeake**	**SSC Charleston**
Initiating	Organize discovery team to develop a proposal to management for launching SPI program	Yes	Yes	Yes	Yes
	Identify business needs and drivers for improvement	Yes	Yes	Yes	No
	Build an SPI proposal	Yes	Yes	Yes	No
	Educate and build support	Yes	Yes	Yes	No
	Obtain approval for SPI proposal and initial resources	Yes	Yes	Yes	No

(Continued From Previous Page)

		Satisfied?			
Phase	**Task**	**NAVAIR**	**SSC San Diego**	**SSC Chesapeake**	**SSC Charleston**
	Establish SPI infrastructure	Yes	Yes	Yes	No
	Assess the climate for software process improvement	Yes	Yes	Yes	No
	Define general SPI goals	Yes	Yes	Yes	No
	Define guiding principles of SPI program	Yes	Yes	Yes	No
	Launch the program	Yes	Yes	Yes	No
Diagnosing	Determine what baseline(s) are needed	Yes	Yes	No	No
	Plan for baseline(s)	Yes	Yes	No	No
	Conduct baseline(s)	Yes	Yes	No	No
	Present findings	Yes	Yes	No	No
	Develop final findings and recommendations report	Yes	Yes	No	No
	Communicate findings and recommendations to organization	Yes	Yes	No	No
Establishing	Select and get training in a strategic planning process	Yes	Yes	No	No
	Review organization's vision	Yes	Yes	No	No
	Review organization's business plan	Yes	Yes	No	No
	Determine key business issues	Yes	Yes	No	No
	Review past improvement efforts	Yes	Yes	No	No
	Describe motivations to improve	Yes	Yes	No	No
	Identify current and future (planned) improvement efforts	Yes	Yes	No	No
	Finalize roles and responsibilities of infrastructure entities	Yes	Yes	No	No
	Prioritize activities and develop improvement agenda	Yes	Yes	No	No
	Reconcile existing planned improvement efforts with baseline findings and recommendations	Yes	Yes	No	No
	Transform general SPI goals to measurable goals	Yes	Yes	No	No
	Create/update SPI strategic plan	Yes	Yes	No	No
	Build consensus, review, approve SPI strategic plan and commit resources	Yes	Yes	No	No
	Form technical working group	Yes	Yes	No	No

(Continued From Previous Page)

		Satisfied?			
Phase	Task	NAVAIR	SSC San Diego	SSC Chesapeake	SSC Charleston
Acting	Complete tactical plan for technical working group	Yes	Yes	No	No
	Develop solutions	Yes	Yes	No	No
	Pilot potential solutions	Yes	Yes	No	No
	Select solution providers	Yes	Yes	No	No
	Determine long-term support needs	Yes	Yes	No	No
	Develop rollout strategy and plan template	Yes	Yes	No	No
	Package improvement and turn over to SEPG	Yes	Yes	No	No
	Disband technical working group	Yes	Yes	No	No
	Roll out solution	Yes	Yes	No	No
	Transition to long-term support	No	Yes	No	No
Leveraging	Gather lessons learned	Yes	Yes	No	No
	Analyze lessons learned	Yes	Yes	No	No
	Revise organizational approach	Yes	Yes	No	No
	Review sponsorship and commitment	Yes	Yes	No	No
	Establish high-level goals	Yes	Yes	No	No
	Develop new/revised SPI proposal	Yes	Yes	No	No
	Continue with SPI	Yes	Yes	No	No
Managing	Set the stage for SPI	Yes	Yes	Yes	No
	Organize the SPI program	Yes	Yes	Yes	No
	Plan the SPI program	Yes	Yes	No	No
	Staff the SPI program	Yes	Yes	Yes	No
	Monitor the SPI program	Yes	Yes	Yes	No
	Direct the SPI program	Yes	Yes	Yes	No

Navy Reports That Its Decentralized Approach to SPI Program Management Has Produced Results

The Navy has delegated SPI responsibility to its commands, which in some cases have further decentralized SPI program management within the command structure. For example, NAVAIR manages its SPI program centrally through its Software Process Improvement Office. Established in 1999, this office, in combination with two NAVAIR executive groups, establishes NAVAIR software improvement policies, monitors performance, and provides support for process training and baselining. In contrast to NAVAIR, SPAWAR decentralized SPI program management to its SSCs.

Navy reports several SPI program benefits. For example, officials at NAVAIR's F/A-18 software program report reaching SW-CMM® level 3 with benefits including cost savings, improved product quality, and a 7:1 return on their SPI investment. In addition, SSC San Diego officials report that their SPI program significantly reduced both the number of software defects and the time expended in testing their air traffic control program system. In particular, staff months spent addressing trouble reports were reduced by 70 percent. These officials also state that benefits from SPI include better management control, improved overall software performance, higher customer satisfaction, and increased competitive advantage and repeat business.

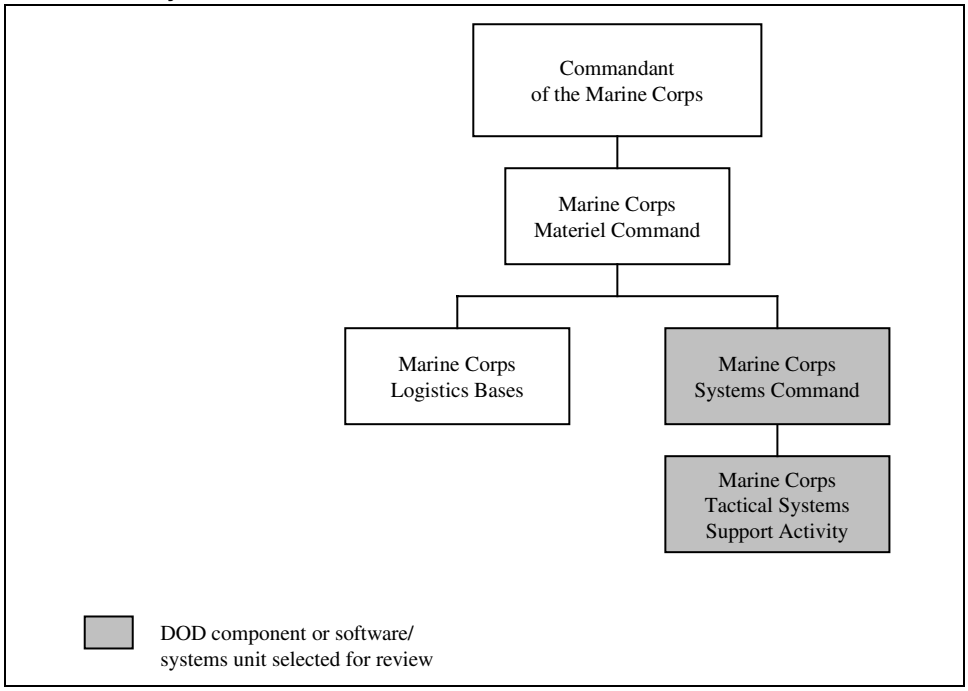
Marine Corps SPI Program

Background

The Marine Corps depends on software-intensive systems to support every facet of its mission—from weapons to tactical communications systems. In fiscal year 2000, the Marine Corps budgeted about $525 million for information technology.

The Marine Corps has assigned responsibility for acquisition, development, engineering, and maintenance of information technology to the Marine Corps Systems Command. The Command is the sole procurement activity for the Marine Corps, purchasing everything from business systems to software-intensive weaponry such as tanks and command, control, communications, and computer equipment. The Marine Corps Tactical Systems Support Activity (MCTSSA), located at Camp Pendleton, California, is a subordinate command. MCTSSA is responsible for software life-cycle support of designated Marine Corps and joint-service tactical data systems and software. (See figure 6.)

Figure 6: Partial Marine Corps Organization Chart Highlighting Units Responsible for Software/Systems



Source: GAO based on Marine Corps data.

According to MCTSSA officials, the Marine Corps does not have a formal SPI program, although it has performed SPI activities since the early 1990s. MCTSSA uses both DOD and Marine Corps guidance to manage its SPI activities.[5] At one time, however, MCTSSA appeared to be on its way to a formal SPI program. It started SPI activities in the early 1990s, and by 1995 was using SEI to support them. For example, during 1995 and 1996 SEI assisted the Marine Corps in identifying program weaknesses and in developing solutions to improve them. However, MCTSSA officials stated that they did not renew the SEI contract because of a lack of funds.

[5]DOD Directive 5000.1, DOD Regulation 5000.2-R, Marine Corps Order 5000.22, and Marine Corps Activity Orders 4130.3 and 4130.4.

Marine Corps SPI Activities Are Partly Aligned With SEI's IDEAL[SM] Model

MCTSSA is performing many of the tasks recommended by the IDEAL[SM] model. Table 11 shows examples of activities that reflect some of the recommended tasks in the IDEAL[SM] model; however, in all but the diagnosing phase, MCTSSA is not executing some key recommended tasks. For example, (1) in the initiating phase, it has not defined general SPI goals or guiding principles; (2) in the establishing phase, it has not developed an SPI plan with measurable goals and committed resources; (3) in the acting phase, it developed solutions but never pilot-tested potential solutions or transitioned the solutions to long-term support; and (4) in the leveraging phase, it gathered lessons learned but did not analyze them or use them to revise its organizational approach. Further, it has not reviewed its sponsorship and commitment, established high-level goals, or decided to continue with the SPI process. Without performing these steps, it is unlikely that SPI activities will produce the kind of meaningful advances in product quality and cost savings that other DOD components have realized. Table 12 shows a detailed comparison of MCTSSA SPI activities against each of the IDEAL[SM] model recommended tasks.

Table 11: Examples of Marine Corps Alignment With IDEAL[SM]

Phase/tasks	Task example
Initiating: *Identify business needs and drivers for improvement*	MCTSSA identified the ever-increasing amount of its resources needed to support software as a business need requiring improvement and determined that changes were needed in its software process and in identifying required resources.
Diagnosing: *Plan for and conduct the baseline of their activities*	SEI performed a study for the Corps that outlined program weaknesses and included recommendations for improvement.
Establishing: *Finalize roles and responsibilities of infrastructure entities*	MCTSSA issued an order that establishes the roles and responsibilities of SPI infrastructure entities, including the commanding officer, technical adviser, business operations manager, division directors, and project officers.
Acting: *Pilot-test potential solutions*	MCTSSA pilot-tested one project.
Leveraging: *Analyze lessons learned*	MCTSSA records lessons learned into a local database that is shared among Marine Corps divisions.

Table 12: Comparisons of Marine Corps SPI Activities With the IDEAL[SM] Model

		Satisfied?
Phase	**Task**	**MCTSSA**
Initiating	Organize discovery team to develop a proposal to management for launching SPI program	Yes
	Identify business needs and drivers for improvement	Yes
	Build an SPI proposal	Yes
	Educate and build support	Yes
	Obtain approval for SPI proposal and initial resources	Yes
	Establish SPI infrastructure	Yes
	Assess the climate for software process improvement	Yes
	Define general SPI goals	No
	Define guiding principles of SPI program	No
	Launch the program	Yes
Diagnosing	Determine what baseline(s) are needed	Yes
	Plan for baseline(s)	Yes
	Conduct baseline(s)	Yes
	Present findings	Yes
	Develop final findings and recommendations report	Yes
	Communicate findings and recommendations to organization	Yes
Establishing	Select and get training in a strategic planning process	Yes
	Review organization's vision	No
	Review organization's business plan	Yes
	Determine key business issues	No
	Review past improvement efforts	Yes
	Describe motivations to improve	Yes
	Identify current and future (planned) improvement efforts	Yes
	Finalize roles and responsibilities of infrastructure entities	Yes
	Prioritize activities and develop improvement agenda	Yes
	Reconcile existing planned improvement efforts with baseline findings and recommendations	Yes
	Transform general SPI goals to measurable goals	No
	Create/update SPI strategic plan	No
	Build consensus, review, approve SPI strategic plan and commit resources	No
	Form technical working group	Yes

(Continued From Previous Page)

Phase	Task	Satisfied? MCTSSA
Acting	Complete tactical plan for technical working group	Yes
	Develop solutions	Yes
	Pilot potential solutions	No
	Select solution providers	No
	Determine long-term support needs	No
	Develop rollout strategy and plan template	No
	Package improvement and turn over to SEPG	No
	Disband technical working group	No
	Roll out solution	No
	Transition to long-term support	No
Leveraging	Gather lessons learned	Yes
	Analyze lessons learned	No
	Revise organizational approach	No
	Review sponsorship and commitment	No
	Establish high-level goals	No
	Develop new/revised SPI proposal	No
	Continue with SPI	No
Managing	Set the stage for SPI	Yes
	Organize the SPI program	Yes
	Plan the SPI program	Yes
	Staff the SPI program	Yes
	Monitor the SPI program	Yes
	Direct the SPI program	No

Marine Corps Uses a Decentralized Approach to Manage SPI Program Activities

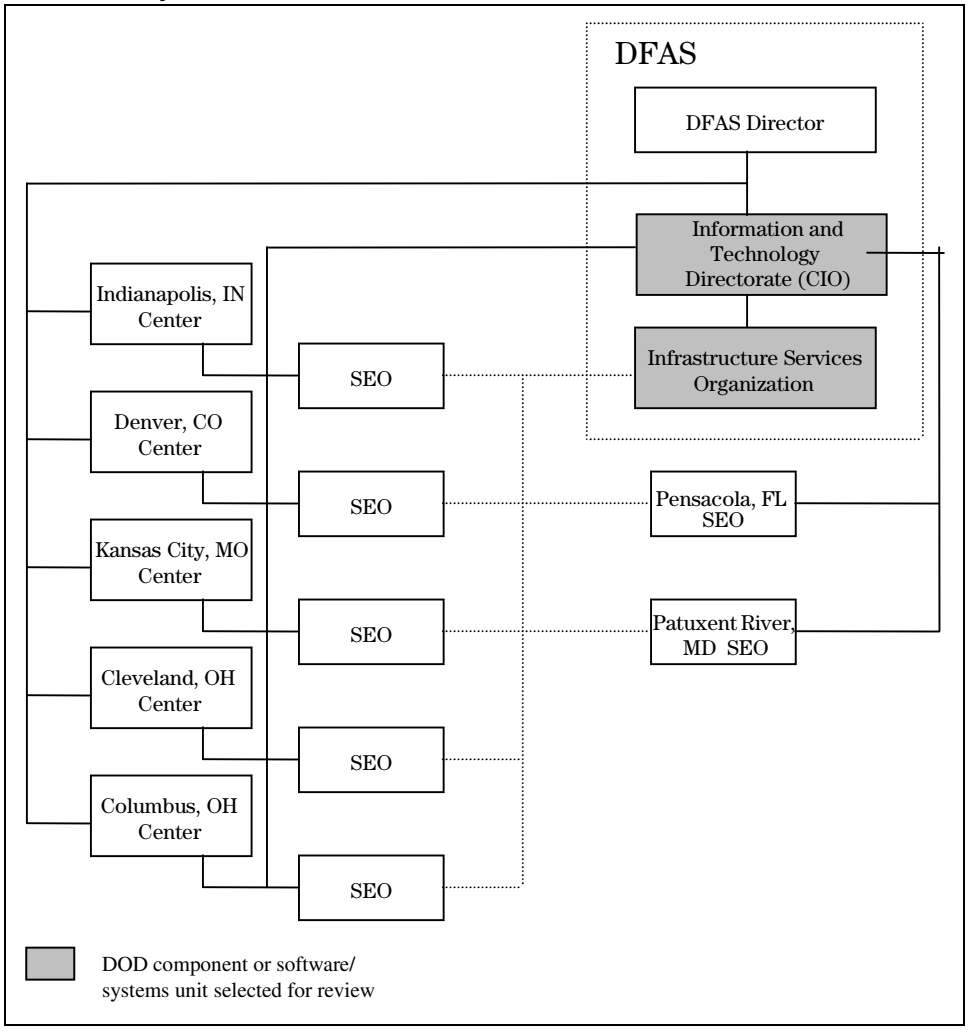
The Marine Corps has adopted a decentralized management approach for SPI by delegating responsibility to the Command, which in turn has delegated most of the responsibility to MCTSSA. Specifically, the Command retained overall responsibility for SPI but assigned other activities, such as defining standard processes or metrics, to MCTSSA.

DFAS' SPI Program

Background

DFAS provides finance and accounting services to DOD components. Created in 1991, it replaced more than 300 service and agency finance and accounting offices that operated more than 300 systems. DFAS consists of five centers and 20 field offices; it operates 83 finance and accounting systems but plans to reduce this number to about 30 or fewer by the end of 2005. The systems are acquired and maintained by seven software/systems units called systems engineering organizations (SEOs). (See figure 7.) In fiscal year 2000, DFAS budgeted about $225 million for information services.

Figure 7: Partial DFAS Organization Chart Highlighting Units Responsible for Information Systems



Source: GAO based on DFAS data.

DFAS began its SPI program in 1993 when responsibility for SPI was assigned to the Financial Systems Organization (FSO) and a corporate SEPG was established to manage the program and coordinate SPI among FSO field locations. FSO established an SPI policy in its 1995 SPI strategic action plan.[6] That policy is currently under revision.[7] The latest draft

[6]FSO policy SM-08.

revision has continuous SPI as an objective for all DFAS SEOs. The policy also requires that best practices be shared across all DFAS SEOs and that process metrics be collected, maintained, analyzed, used, and reported to support the SPI process.

DFAS SPI Program Is Aligned With SEI's IDEAL^{SM} Model

DFAS' SPI program is fully consistent with the IDEAL^{SM} model. Table 13 shows examples of DFAS activities that reflect some of the recommended IDEAL^{SM} tasks; table 14 shows a detailed comparison of DFAS SPI activities with each of the IDEAL^{SM} model recommended tasks.

Table 13: Examples of DFAS Alignment With IDEAL^{SM}

Phase/tasks	Task example
Initiating: *Document the organization's SPI approach, business needs, and team roles*	DFAS published its original SPI action plan, which specified an approach, business needs, and team roles, in 1995.
Diagnosing: *Plan for and conduct baselines*	In 1996 DFAS used SEI methods to evaluate process maturity at each field location.
Establishing: *Identify successful practices to leverage and unsuccessful practices to avoid*	DFAS has a post-implementation review at one site that uses staff input to identify best practices for each completed project; in January 2000 it identified barriers to SPI success and publicized these at a DFAS conference.
Acting: *Install solutions across the organization*	DFAS completed a review of current software practices in 2000 and developed a schedule to update the current practices to be consistent with CMM® level 3.
Leveraging: *Accumulate lessons learned and use them to improve the software process*	DFAS established a corporate process asset library and plans to link local libraries to it so information can be shared across the agency. One site has a postimplementation review program that uses metrics to evaluate a project, analyze potential issues, develop an action plan, and develop training to improve the process.

[7]DFAS Regulation 8000.1-R.

Table 14: Comparisons of DFAS SPI Activities With the IDEAL[SM] Model

Phase	Task	Satisfied?
Initiating	Organize discovery team to develop a proposal to management for launching SPI program	Yes
	Identify business needs and drivers for improvement	Yes
	Build an SPI proposal	Yes
	Educate and build support	Yes
	Obtain approval for SPI proposal and initial resources	Yes
	Establish SPI infrastructure	Yes
	Assess the climate for SPI	Yes
	Define general SPI goals	Yes
	Define guiding principles of SPI program	Yes
	Launch the program	Yes
Diagnosing	Determine what baseline(s) are needed	Yes
	Plan for baseline(s)	Yes
	Conduct baseline(s)	Yes
	Present findings	Yes
	Develop final findings and recommendations report	Yes
	Communicate findings and recommendations to organization	Yes
Establishing	Select and get training in a strategic planning process	Yes
	Review organization's vision	Yes
	Review organization's business plan	Yes
	Determine key business issues	Yes
	Review past improvement efforts	Yes
	Describe motivations to improve	Yes
	Identify current and future (planned) improvement efforts	Yes
	Finalize roles and responsibilities of infrastructure entities	Yes
	Prioritize activities and develop improvement agenda	Yes
	Reconcile existing planned improvement efforts with baseline findings and recommendations	Yes
	Transform general SPI goals to measurable goals	Yes
	Create/update SPI strategic plan	Yes
	Build consensus, review, approve SPI strategic plan and commit resources	Yes
	Form technical working group	Yes

(Continued From Previous Page)

Phase	Task	Satisfied?
Acting	Complete tactical plan for technical working group	Yes
	Develop solutions	Yes
	Pilot potential solutions	Yes
	Select solution providers	Yes
	Determine long-term support needs	Yes
	Develop rollout strategy and plan template	Yes
	Package improvement and turn over to SEPG	Yes
	Disband technical working group	Yes
	Roll out solution	Yes
	Transition to long-term support	Yes
Leveraging	Gather lessons learned	Yes
	Analyze lessons learned	Yes
	Revise organizational approach	Yes
	Review sponsorship and commitment	Yes
	Establish high-level goals	Yes
	Develop new/revised SPI proposal	Yes
	Continue with SPI	Yes
Managing	Set the stage for SPI	Yes
	Organize the SPI program	Yes
	Plan the SPI program	Yes
	Staff the SPI program	Yes
	Monitor the SPI program	Yes
	Direct the SPI program	Yes

DFAS Reports That Its Centralized Approach to SPI Program Management Has Produced Results

DFAS centralized SPI program management when it started its program under FSO in 1993. When reorganized in 1998, DFAS retained centralized SPI management by assigning it to the Infrastructure Services Organization (ISO). Under the draft SPI policy revision, management of the program will still be centralized in headquarters, but responsibilities will be split between ISO and its parent unit, the Information and Technology Directorate (ITD). Specifically, the draft revision assigns the ITD responsibility for approving SPI policies, maintaining metrics, and analyzing metrics for the purpose of recommending changes in priorities, resources, and processes. The draft revision assigns the ISO responsibility for publishing SPI policies, maintaining the agency process assets library, and coordinating DFAS-wide SPI activities.

ITD reports that its SPI program has improved DFAS staff productivity. A DFAS contractor has conducted benchmarking measurements on DFAS software/systems development efforts. Results from 1996 and 1997[8] measurements show that DFAS develops and maintains software (measured in terms of function points[9]) for $0.67 that costs an average organization $1.00, a comparable government organization $1.06, and a comparable large commercial organization $1.37. The contractor cited "strong processes" as one factor that contributed to DFAS' productivity.

DLA's SPI Program

Background

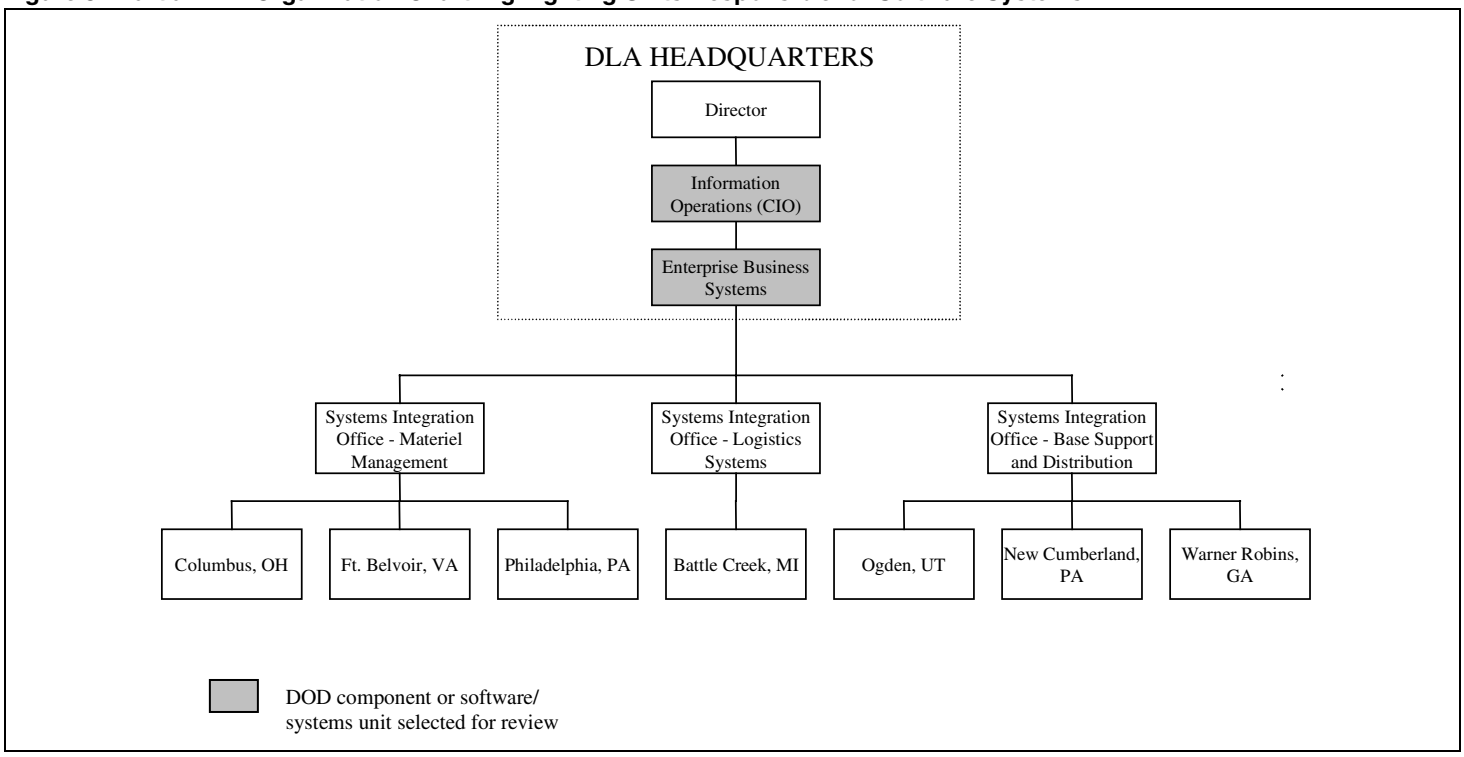
DLA is a combat support agency whose primary role is to provide supply management, logistics services, and distribution support to America's military forces worldwide. It relies on software-intensive systems to administer over $900 billion in DOD and other agency contracts. DLA budgeted about $784 million for information technology in fiscal year 2000.

In 1998, DLA's systems design center operated nine systems development and maintenance units across the country. After closing this center in December 1998 in order to streamline operations and reduce costs, DLA created three systems integration offices to oversee the development and maintenance units, which have been cut from nine to seven. (See figure 8.) Each of the three offices supports software development and maintenance for a separate DLA business function—materiel management, logistics, and base support and distribution.

[8]Results from 1998 and 1999 measurements are not yet available.

[9]Function points are software-size estimates based on the number and complexity of inputs, outputs, files, inquiries, and interfaces for a functional unit of software.

Figure 8: Partial DLA Organization Chart Highlighting Units Responsible for Software Systems



Source: GAO based on DLA data.

DLA does not have an SPI program, having eliminated the program in 1998 when its system design center was closed in 1998. However, as part of its ongoing reorganization, DLA rewrote the policy and duties of its CIO and moved that function to the new Information Operations unit. The CIO told us that the SPI program is to be reestablished. However, specific plans and milestones for doing so were not available.

GAO Contact and Staff Acknowledgments

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