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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1 REPORT NUMBER	12 GOVT ACCESSION NO.	3 RECIPIENT'S CATALOG NUMBER
	AD-P128917	
4 TITLE (and Subtitle) A Candidate Strategy For The Software Engineering Institute		5 TYPE OF REPORT & PERIOD COVERED
		6 PERFORMING ORG. REPORT NUMBER
7 AUTHOR(s) The DoD Joint Service Task Force on the Software Initiative		8 CONTRACT OR GRANT NUMBER(s)
9 PERFORMING ORGANIZATION NAME AND ADDRESS		10 PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11 CONTROLLING OFFICE NAME AND ADDRESS Deputy Under Sceretary of Defense Research & Advanced Technology Washington, D.C. 20301		12 REPORT DATE March 15, 1983
		13 NUMBER OF PAGES
14 MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15 SECURITY CLASS. (of this report) Unclassified
		15a DECLASSIFICATION/DOWNGRADING SCHEDULE

16 DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17 DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Unclassified

DTIC
ELECTED
JUN 0 3 1983
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18 SUPPLEMENTARY NOTES

19 KEY WORDS (Continue on reverse side if necessary and identify by block number)

Software Engineering Institute, Embedded computers, technology insertion, Ada, systems interface standards, STARS, APSE, training, state-of-the-practice, mission critical systems, software technology, hardware.

20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document describes the mission and concept of the Software Engineering Institute and discusses proposed operational characteristics and organizational and management alternatives. This document represents an extension of the work initiated by the STARS workshop, February 7-9, 1983.

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A CANDIDATE STRATEGY FOR THE

SOFTWARE ENGINEEERING INSTITUTE

March 15, 1983

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1.0 INTRODUCTION

The establishment of a Software Engineering Institute (SEI) is proposed as a part of the DoD Software Technology for Adaptable and Reliable Systems (STARS) Program. This Plan describes the concept and mission of the SEI and discusses proposed operational characteristics and organizational and management alternatives. The document represents an extension of the work initiated by the STARS workshop, February 7-9, 1983.

The STARS Program has been established to advance the state-of-the-art and practice in software engineering of DoD embedded computer systems (ECS). This program will make a significant impact on the rate of research in software technology -- software engineering techniques and tools. However, this impact will not have a corresponding effect on the state-of-practice in the DoD and the defense industry unless the technology can make the transition to application use. The SEI is to provide a vehicle for the effective transition of new software engineering techniques and tools.

Software Engineering Institute

*The purpose of the (SEI) is to bring to the DoD Services and Agencies the best available tools and techniques for the efficient design and production of reliable and adaptable software. It will maintain a state-of-the-art software development environment and take the lead in developing Systems Interface Standards to maintain compatibility among standard environment adopted by the Services. The SEI will evaluate new techniques, integrate

promising tools into the environment, demonstrate their effectiveness for DoD projects, and provide training, documentation and user assistance.

This document describes the characteristics and operations of the Software Engineering Institute along with the issues and alternatives surrounding its establishment. The document reflects the comments provided by attendees of the STARS workshop held February 7-9, 1983. The foundation for the document is prepared in section 2 in which the problems of technology transition are discussed. Particular emphasis is placed on software engineering environments and their role in technology transition. Section 3 presents the mission, objectives and functions of the Insititute. A discussion of what the Insititute will do is complemented by a brief description of how it might operate and the types of personnel required.

The Institute support base, management, hosting, and relation to STARS were key areas of discussion at the STARS workshop. There are many alternatives to consider. Section 4 outlines the issues, the alternatives and recommended approach in each of these areas. Section 5 presents an implementation plan that is sufficiently generic to apply to most alternatives discussed in Section 4.

2.0 BACKGROUND

This section briefly discusses technology insertion in general and specifically for software technology. Software development and support environments are characterized and contrasted. The characteristics of defense embedded computer systems are described. Finally, the Ada Programming Support Environment is noted and initial assumptions are stated.

2.1 TECHNOLOGY INSERTION

To be effective, technology advancements must be integrated with the technology state in active use. Unless a totally new paradigm for software production and in-service support is being introduced, new tools and technology must be engineered so that they can function in existing environments and can be used harmoniously in conjunction with existing techniques and practices. This involves the solution of interface and data representation problems. It also involves the investigation of usage modes which allow mutually supportive use of the new and existing techniques and practices.

To have effect on the state-of-the-practice, technology advancements must be delivered to practitioners. The technology must be packaged in a conveniently usable form, transferred to practitioners' organizations, and supported after being transferred. Also, practitioners must be taught how to use the new technology. Thus, delivery involves the solution of

many problems concerning usability, human engineering, utility demonstration, education, maintenance, and enhancement.

Considerable resources are required to package, integrate, and deliver new software engineering tools and techniques. The process involves evaluating technology, packaging it with proper human engineering characteristics and documentation, integrating it with other accepted techniques and tools, providing proper training, and providing life cycle support. As noted in the following section, neit.er the research organizations nor the development and support organizations have budgeted for these activities. Without budgets specifically earmarked for this purpose, transition of technology will continue to be slower than considered desireable. There is a natural resistance by development and support personnel to new methods of software development and support. This resistance is also a factor in slowing the transition of software engineering technology.

The combined result of these circumstances causes significant gap between the state-of-the-art and the state-of-the-practice in software engineering. To get the maximum benefit from the STARS Program and other software engineering research, this gap must be narrowed. Conventional approaches to this problem have not been effective enough. A Software Engineering Institute will provide the proper focus to make a positive impact on this problem.

2.2 SOFTWARE TECHNOLOGY-RESEARCH, DEVELOPMENT AND APPLICATION

The effective integration and delivery of software engi-neering technology is not occurring fast enough in defense systems today. Although much useful research is conducted, too little technology packaging and transfer to operational use is accomplished. There are reasons for this slow transfer of technology.

Technology research usually is performed by organizations different from those that develop and support application software. The mission of these research organizations is to develop innovative techniques and tools for software engineering. This mission does not include packaging, integration, and delivery of this technology. The organizations that develop and support applica-tion software are totally absorbed in meeting schedules and operational objectives. They are motivated to avoid risk and have little incentive to bring new software engineering tech-nology into their operation. Therefore, there is a gulf between the R&D organizations and the software development and support organizations that stifles the transfer of technology.

2.3 SOFTWARE DEVELOPMENT ENVIRONMENTS

Because the current state-of-the-practice of software engineering is characterized by diverse and incompatible techniques and tools, the introduction of new techniques and tools usually causes considerable disruption. This disruption

is caused by required reorientation of processes and conversion activities, e.g., conversion of code from assembly language to a structured high order language (HOL) to take advantage of the HOL and structured programming techniques.

The software scene is one of thousands of unique development teams, each with its own particular set of tools and practices - its own environment. Commonality of tools and practices is found on a small scale, here and there. A multitude of development environments are used by DoD's software developers; different host computers, different operating systems, different tools, utilities, editors and so on. There are subtle differences between different versions of languages, between different hosts, between different compilers, between different code generators.

In the long run, it is inefficient for DoD to apply multitudes of inconsistent development environments. Economy of scale is non-existent. The DoD pays, directly or indirectly, for upgrades of all of these environments as each developer discovers new and better tools and uniquely applies them to his own environment. Given the current state in which substantial development and experimentation is needed, coordinated development of different approaches is appropriate, but there must be a clear path toward development of commonality and standard interfaces.

2.4 IN-SERVICE SUPPORT ENVIRONMENTS

When the software product enters the operational and service support phase, the product is supported by one of a few central groups. The diversity of development environments is in contrast to the few centralized software product support centers. However, these few centers must obtain and maintain unique environments for each supported system. The reasons for this are several, but one stands out: Each operational software product that results from a given environment is most safely supported (modified or fixed) if the needed work is accomplished on the same environment on which it was developed. Thus the many development environments must be maintained by the support centers. Even though the essential differences are at the level of methodology with a conceptually similar but differently implemented base. Support center personnel are taxed by the requirement to understand the nature and subtleties of all the development environments of the products they support. Again, no economy of scale.

A major mismatch exists between the DoD community's development environments and DoD's in-service support environments in number, in kind, and in tools. This mismatch consumes scarce critical human resources and does not support portability of people among projects.

2.5 DEFENSE EMBEDDED COMPUTER SYSTEMS

Virtually every system in the current or planned inventory makes extensive use of computer technology. Computers are integral to our strategic and tactical systems. They control the targeting and flight of missiles, they coordinate and control the sophisticated systems of high performance aircraft, they are at the heart of the defense of carrier battle groups, and they integrate the complex activities of battlefield command. The software of these computers operating in real time performs both component control functions and the integration functions of inter-component communication and control. In a large sense the software is the system. Potentially a system function embodied in software may be modified to improve the weapon system capability or meet new threat characteristics. The computer resources -- hardware and software -- are inextricably part of a larger system and are in reality subsystems embedded in the system. Such computer hardware and software are called embedded computer systems (ECS) or embedded computer resources (ECR). Defense embedded computer systems are qualitatively different than other uses of computers! These systems have the following characteristics:

a. Although not all systems are large, all are very complex. Many are extremely large. Single unified systems of 1,000,000 lines of code are commonplace.

b. Most ECS systems operate in real time. ECS are
    required to respond in milliseconds to a complex
    threat. They operate on sensor data and provide
    controls of high performance aircraft and missiles.

c. Many defense ECS systems have the property of
    catastrophic consequence of failure. Examples are
    air defense and ballistic missile warning systems
    and nuclear weapon command and control systems.

d. There is intense human interaction with many ECS
    such as command and control systems where decision
    mechanisms are shared by operators and in flight
    systems where the ECS responds to and assist the
    pilot in aircraft control.

e. Defense ECS have long lives. Some may be operational
    for 20 years of more.

f. During the life of the ECS, it must be able to be
    modified and adapted to meet new threats, accommodate
    new weapons, operate in changing operational scenarios
    and tactical roles.

g. Most ECS applications in the DoD are designed and
    developed for the first time by the DoD. Defense
    agencies require that the state-of-the-art in weapon
    systems be pushed.

The above can be summarized in part by the following state-
ments:

a.   DoD use of embedded computer resources define the
     extreme ends of the characteristics listed above.
     These systems push the state-of-the-art in applica-
     tions. No commercial use of computers hits the ex-
     treme ends of all of the characteristics above as
     consistently as do DoD systems.

b.   DoD requirements leads the way in most ECS technology
     applications, just as the DoD leads in research and
     technology application of jet propulsion, and large
     jumbo aircraft. The fallout to industry follows in
     commercial systems applications.

Many companies develop computer resources -- computer
hardware and software -- for DoD applications as well as for
commercial applications. However, few spend significant funds
for computer resource technology development and transition to
meet the demands of military systems. Their R&D concentration
is in the larger commercial market where the investment leverage
is greater. Specific efforts must be aimed at the singular
DoD MCCR (Mission Critical Computer Resources) and ECR (Embedded
Computer Resources) software.

2.6 THE ADA PROGRAMMING SUPPORT ENVIRONMENT

The Ada®* Program, serving as a cornerstone for the STARS Program, has defined the concept of an Ada Programming Support Environment (APSE). It is built upon common interfaces and data representations for automated tools. This APSE concept is being adopted by all three Services to aid in the development and support of Ada-based software. The Services are committed to consistency in the Kernel APSE to permit tool sharing.

The Ada Program developments are directed to the computer programming process. However, the APSE concept provides a basis for further development of a shared environment of tools supporting signficantly more of the software engineering process.

2.7 ASSUMPTIONS

The SEI is proposed as the vehicle to redress the problems of technology transition. The plan for the SEI is based on the following assumptions:

a. In order to fully realize the objectives of the STARS program, a mechanism for technology transition is required.

b. The problem of technology transition cannot be solved fast enough within the current DoD organizational structure or funding.

* Ada is a trademark of the U.S. Government (AJPO)

c.   ECS software development exhibits characteristics
     not usually encountered in commercial ADP software.
     Industry and academia are concentrating on ADP
     technology, not as much on ECS technology. The
     DoD will take advantage of gains provided by these
     commercial efforts. They will be used by DoD
     when applicable and engineered for use by the SEI,
     but they will not be enough.

d.   To ensure that the problem is defined properly and
     addressed for all of the DoD ECS community, the main
     mechanism for transition - the SEI - should be funded
     by and should be under the control of DoD.

e.   Ada will be widely accepted and the kernel APSE-based
     support environment will serve as a powerful vehicle
     for technology integration and delivery.

f.   The DoD has a large investment in assembly-level
     language software and in high-order-language (other
     than Ada) software that will be in the operational
     inventory for some time to come -- 10 to 20 years.
     This software may be supported more efficiently if
     new technology is brought to bear where practical.

g.   A significant investment of resources over an extended
     period will be required.

h.   Success will depend on the cooperative involvement
     of researchers, industry, and DoD software organizations.

3.0 MISSION, OBJECTIVES, FUNCTIONS AND GENERAL DESCRIPTION OF THE SOFTWARE ENGINEERING INSTITUTE

The Software Engineering Institute's Mission is to improve the state-of-the-practice of software engineering in the DoD community. Specifically, the Institute is to be established to bridge the gap between software technology development and application. The gap is between advanced development and production in a classical systems acquisition life-cycle sense and the bridge is defined as engineering development.

To accomplish the mission stated above, the SEI has four objectives.

o First, the SEI will assimilate software technology advances from the DoD technology base and other sources.

o Second, the SEI will engineer appropriate tools, methods and techniques and supporting technology to function efficiently in the DoD software environments.

o Third, it will support the effective transition and application of software engineering technology to DoD system development and support.

o Fourth, the SEI will perform research in methods and tools supporting its assimilation, engineering, and transition activities.

3.1 PRIMARY FUNCTIONS OF THE SOFTWARE ENGINEERING INSTITUTE

The four objectives translate into fifteen SEI functions as shown in Figure 1. Those are the basic functions required to carry out the objectives to meet the mission. Additional functions or activities may also be carried on at the Institute. Some of these are described in section 3.2.

Key to the functioning of the Institute will be its software environment. This environment must provide the technology basis and interface standards for the Services to derive Service standard environments. The Institute's environment will be easy to port to other sites, and can serve as the basis for value added efforts by others. Maintained by the Institute, it will be the most advanced environment as the Institute integrates the newest technology into it. A KAPSE-based environment will be the standard as soon as practical.

3.1.1 The Functions of Assimilation

The Institute will foster the identification and evaluation of valuable new technologies in several ways. First, it will provide a "laboratory" for the experimental evaluation of utility and the comparison of alternatives. This laboratory will have, as its basis, a support environment through which new technology can be embodied as tools and, in this form, be applied to both experimental and real problems. Second, the Institute will encourage the development of metrics for assessing the utility

| SEI OBJECTIVES | SEI FUNCTIONS |

SEI OBJECTIVES   **SEI FUNCTIONS**

1. Assimilate software
   technology advances
   from DoD technology
   base and other sources.

    1. Evaluate state-of-practice
   to determine and under-
   stand needs for advanced
   technology tools or techniques

    2. Identify new technology
   advances.

    3. Evaluate alternatives.

2. Engineer appropriate
   tools and techniques
   to function efficiently
   in DoD software develop-
   ment environments.

    4. Select tools to meet needs.

    5. Integrate and package new
   techniques or tools into the
   DoD standard environments.

    6. Demonstrate the utility of the
   newly integrated technology.

3. Support the effective
   transition and applica-
   tion of software engi-
   neering technology to
   DoD system development
   and support.

    7. Advocate new tools and
   techniques.

    8. Assist in initial appli-
   cation environment.

    9. Provide training.

    10. Provide support of
   delivered tools.

Figure 1. SEI Objectives and Functions.

4. Perform research in methods and tools supporting the assimilation, engineering, and transition activities of the SEI.

11. Define a taxonomy of software functions

12. Develop techniques for integrating existing tools into an environ-

13. Research the sociological and psychological aspects of transition.

14. Develop metrics for evaluation of SEI technology projects.

15. Conduct continuing research in software engineering environments.

Figure 1:   (Continued)

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of aids. Finally, the Institute will encourage the collection
and cataloging of data from alternative aids.

3.1.2 The Functions of Engineering

New technology developments require engineering development
effort following initial proof of feasibility. New tools need
to be interfaced to the environment in which they are to be
used. Proposed new techniques may need to be modified to work
in an environment different from the one where they were
developed. After integration, these tools and techniques must
be documented and training material must be developed to assist
in their introduction into a user's environment.

The Institute will select advanced tools and techniques
and integrate them into its environment. In accomplishing the
engineering integration task, it will attempt to engineer each
new tool so it is consistent with evolving systems Interface
Standards so they can be integrated into service standard
environments as easily as possible.

This engineering-integration function will be paralleled
by the constant evaluation of the SEI's advanced environment,
the Service's environments and industry environments where
the Institute's tools are to be applied. The Institute's
environment will evolve; however, its evolution will be
influenced by these other environments. The Institute's
environment must always remain an effective vehicle for
transition of new tools to the user environment.

3.1.3 The Functions of Transition

The Institute will advocate, assist, train, and provide follow-on support to effectively transition new tools and techniques. The Institute will be uniquely able to advocate its new environment-integrated tools and techniques. The Institute will have focused on the practical needs when searching among new technology developments for solutions. Utility demonstration, both in and outside the Institute, will add confidence to new tools to be transitioned.

The Institute will provide assistance and training to Service organizations to facilitate transition. The Services will in turn, effect transition from their support system standardization organizaitons to their system development contractors. The Institute will provide limited support directly to a contractor site when requested by the appropriate Service organization.

3.1.4 The Functions of Research

The Institute will conduct research in support of its primary activities of assimilation, engineering, and transition. The major research focus will be on software environments. Since an advanced environment will be the vehicle for technology integration and transition, the Institute will conduct continuing research in this area to ensure it maintains the most advanced production environment feasible. Related research will investigate methods of defining interfaces for the integration of existing tools.

Other important research tasks of the Institute will be directed to better cataloging of software system functional components, the sociological and psychological aspects of transition, and metrics for evaluating new technologies. The results of these tasks will be important to the successful operation of the Institute.

3.2 TRAINING AND OTHER FUNCTIONS

In addition to the primary functions of the SEI, it will provide training and professional services. These activities will enhance the role of the Institute as a transition agent.

The Institute will educate about 200 educators per year. The education provided will be on a graduate level. New state-of-the-practice tools and research results will be taught. Languages and computer science are undergraduate efforts and will not be taught.

The Institute also will provide training on the installation and use of its advanced environment and other products. This training will include courses in methods, tool useage, product tailoring and installation.

Professionals could be added to the Institute staff and supported on a fee-for-service basis, similar to the manner in which 75 people are employed at the Federal Computer Performance and Simulation Center in Washington, D.C., called Fed-Sim.

Projects and entities separate from the Institute will buy consultation or services from the Institute and pay for those services on an as-used basis. (Such work by the Institute staff provides an excellent method of staying in touch with the state-of-the-practice of software engineering.) The use of this support device would not be limited to supporting DoD only, nor government agencies only, although they would be the major focus.

Use of the Institute's advanced environments on a service bureau basis will generate additional resources.

The Institute will conduct a constant review of software technology and practice world-wide. It will be one of the repositories of DoD's expertise in the area. With the intimate knowledge of its in-house showcase environment and research, a worldwide review of research and practice, and a connection to the rest of the work underway in the STARS effort, the Institute is ideally situated to perform this critical role. It will be a national resource for this role alone.

3.3 OPERATIONAL ENVIRONMENT

The operational role of the SEI as a mechanism for technology transition is depicted in Figure 2. Software engineering technology emerging from research organizations will be captured by the SEI. The primary source of this research technology will be DoD laboratory projects funded both by on-going Service research programs
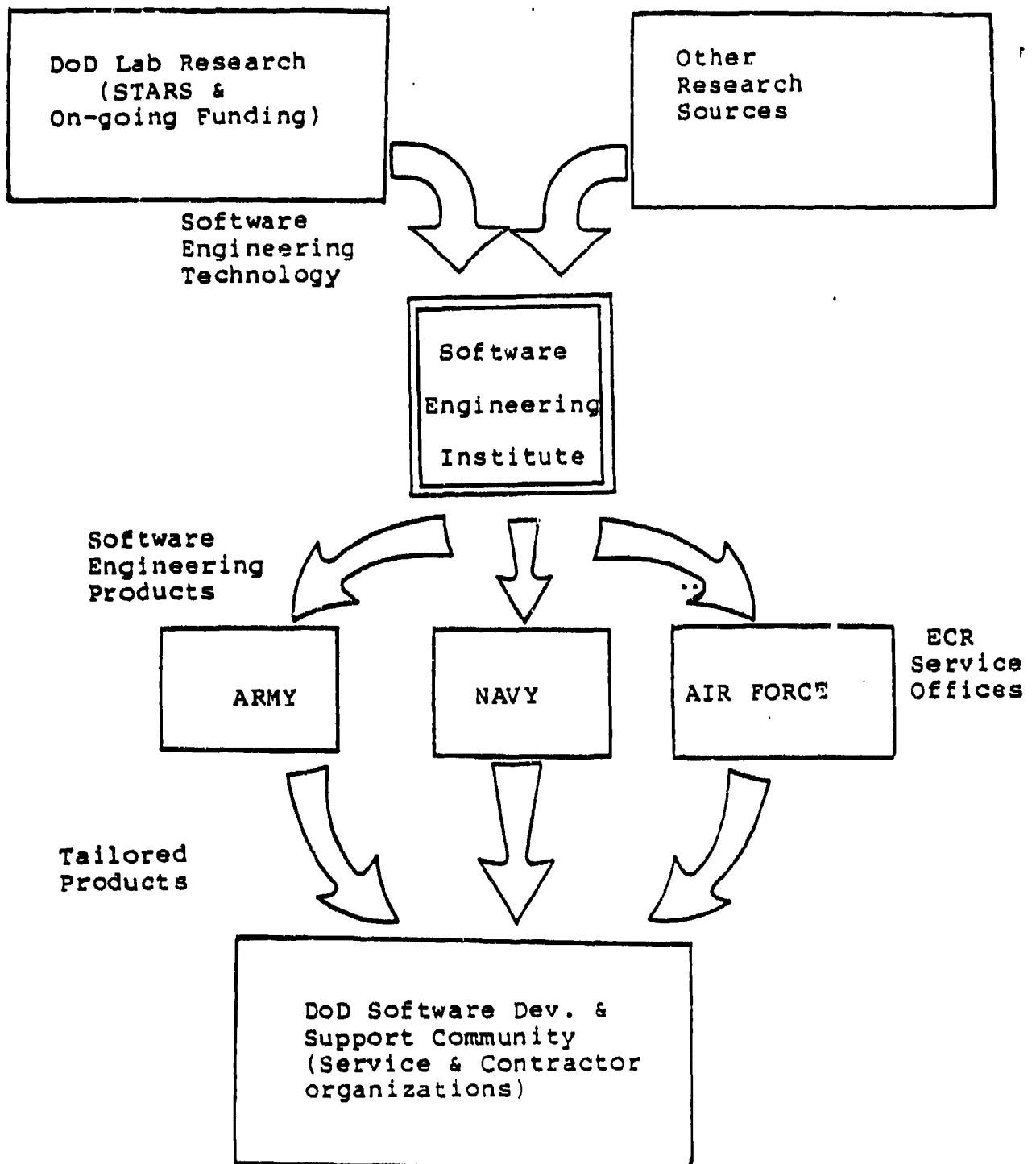
Figure 2. The SEI Transition Role.

and by STARS. Non-DoD research organizations also will be sources
of the technology captured by the SEI. The research technology
will be integrated and packaged by the SEI and the resulting
products will be distributed to Service organizations responsible
for standard ECS software support tools. These organizations,
in turn, will tailor the products to their needs and distribute
them to their respective software development and in-service
support organizations. The products will be made available to
DoD contractors.

Since the SEI will have limited resources, it is not ex-
pected that all technology insertion will occur as shown in
Figure 2. The Services and DoD contractors will continue to
integrate research technology from the DoD laboratories and
other sources into their operational support systems as the
need arises.

Within the SEI, operations can be viewed as a pipeline for
the evaluation, integration, and delivery of software engineering
technology. Figure 3 provides a simplified view of the SEI internal
organization. The Research Division (RD) initializes the
pipeline by selecting promising technology for evaluation.
That technology that passes the RD evaluation filter is passed
to the Outreach Division (ORD) for packaging and integration.
ORD establishes a project for packaging and integration. Pilot
evaluation in a real project environment also may be attempted.
The Products Division (PD) personnel will be included in the
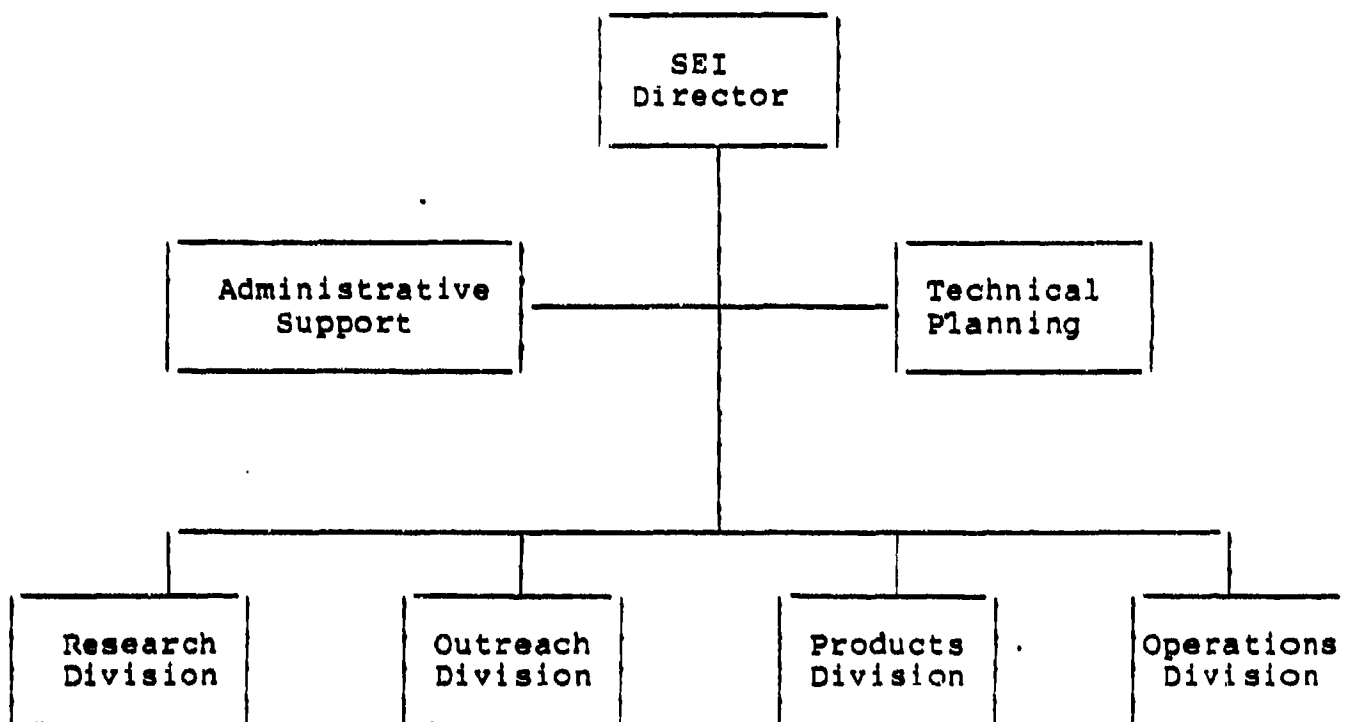
Figure 3:   A Representation of the Internal Organization of the SEI

integration activity. PD will ensure the technology meets packaging and integration standards and then release the technology to the DoD community in a support environment. PD will provide training support to the Services. The Operations Division (OD) will support the pipeline activities with computer and communiations equipment and systems engineering expertise, if required.

The performance of the SEI in meeting its technology objectives will be continually evaluated and the results will be presented to OUSD (R&AT) management periodically (quarterly or annually). This process is shown in Figure 4. The objectives set in the SEI Operations Plan will be reviewed and approved by OUSD(R&AT) management before the start of the plan period. Once the plan is implemented by the SEI divisions, the Operations Division will have the responsibility of collecting effectiveness measure data and preparing performance reports for SEI management. The data might include resource utilization against plan, number of projects passed from Research to Outreach, number of pilot project transition successes, etc. SEI management might redirect the Divisions based on review of the reports. Quarterly and/or annually, the SEI performance record will be presented to OUSD(R&AT) management. OUSD(R&AT) management might redirect the SEI based on the information presented.
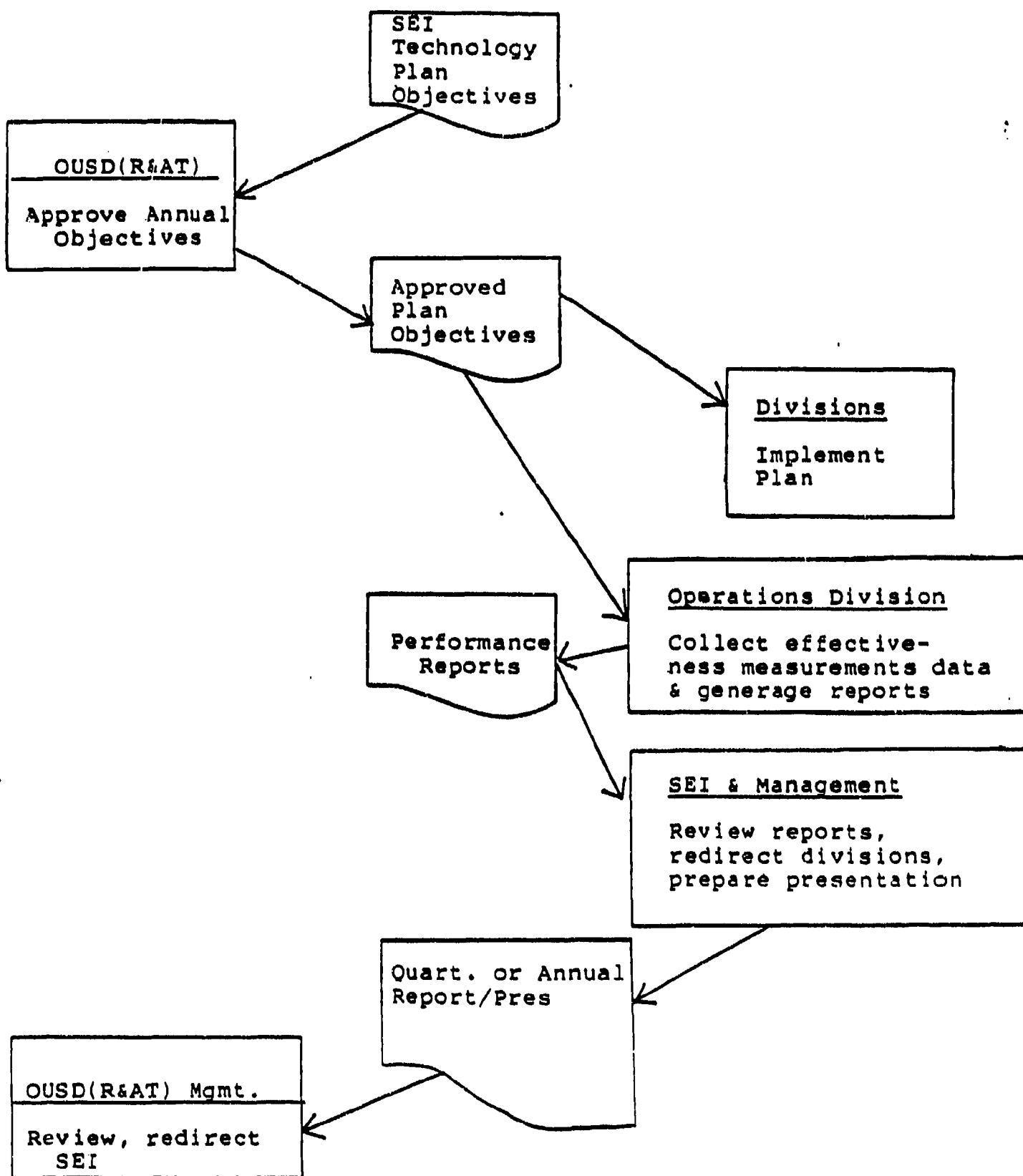
Figure 4. SEI Performance Evaluation

3.4 SEI DIVISION ACTIVITIES

A more detailed discussion of the functions and activities of the SEI divisions follows in sections 3.4.1 through 3.4.4.

3.4.1 Research Division

The Research Division (RD) has four important functions. The first is to maintain an up-to-date picture of research activities related to software engineering. The second is to evaluate promising technology. The third is to nominate technologies as candidates for Outreach project initiation. The fourth is to conduct research in metrics, testing, technology insertion, and cataloging of software. An up-to-date status of software engineering technology research will be published semi-annually. Research projects worldwide in academia, government, and industry will be addressed. The majority of information will be collected through surveys and literature searches. Other sources will include the DoD Independent Research and Development (IRAD) Program and professional conferences. The information will be electronically encoded for access via the ARPANET.

On a continuing basis, RD will evaluate the research technology survey data to identify technology that has near-term practical payoff potential. This process will be based on the following criteria:

a. State of development - the technology must be at a stage of development which is sufficiently stable for transition.

b. Applicability to DoD - the technology must have aplicability to the development or support of DoD embedded computer systems.

c. Payoff - the technology must offer the potential for significant payoff in terms of increased productivity, reliability, or quality.

d. Successful transition - the probability of success of transition must be commensurate with the potential payoff.

e. Title to rights - there must be no encumbrances regarding the rights of the DoD community (including DoD contractors) to utilize the technology.

f. Cost - the cost of packaging, integration, transition, and life cycle support must be commensurate with the potential payoff.

g. Personnel availability - the personnel required to man the related ORD project must be available.

This process will require that part of the staff perform field activities to evaluate technology where the research is being conducted. Grants may be sponsored by RD to fund the evaluation

of certain technologies. Some projects in this Division will
be in direct support (on-site) of ongoing DoD projects, perhaps
in a V&V role.

On the basis of the filtering evaluation process, promising
technologies will be identified. RD will rank these technologies
againist those currently being addressed by ORD and against
internal SEI research projects concerning transition and inte-
gration. Based on the results of the ranking, certain technol-
ogies will be nominated for ORD project initiation. These
nominations will be factored into the SEI planning process by
SEI management. Other factors considered will be the Product
Division product development plan and assessment of DoD needs.

The RD will conduct research in support of its mission.
This research will include methods of cataloging software
system functional components, the sociological and psychological
aspects of transition, and metrics for evaluating new technologies.
The results of these tasks will be important to the successful
operation of the Institute.

3.4.2 The Outreach Division

The Outreach Division (ORD) primarily will be responsible
for the initiation and management of projects. Most of the
projects will be concerned with the packaging of new technology
and its integration with the support environment. Projects
also may be addressed to technology evaluation, or research

into transition aids and technologies. Some of this evaluation will occure through technology trials on DoD production projects.

Each year, as part of the planning process, on-going projects will be evaluated and ranked against new technologies nominated by RD. Based on this planning activity, the projects for the coming year(s) will be proposed. This may involve cancellation of on-going projects which are not progressing satisfactorily. The evaluation of on-going projects will be based on the projected technical objectives and the project plan. Measurements against these objectives and the plan will be made throughout the year to give SEI management a clear picture of progress.

The project teams will be manned by visiting scientists, SEI permanent staff, and support contractors. The nucleus of a project will be manned by the visiting scientists. Ideally, the project leader will be a leader in the field of software engineering and active in research in the technology area that is the focus of the project. He will be supported by visiting professionals from the Services and industry who have proven skills in software engineering. Project management support will be provided by the SEI permanent staff. For large projects, additional technical support will be provided by Products Division and support contractors.

When visiting scientists and professionals complete
their term with the SEI, they will become powerful instruments
of transition by spreading in their parent organization the
software engineering techniques and approaches learned at
the SEI.

In some cases, it may not be possible to get the lead
scientist required for a project to attend the SEI. Under
the right circumstances, the project might be sponsored under
an SEI grant to the parent organization of the individual.
In this case, evaluation would be performed under the same
ground rules used for the ORD internal projects.

3.4.3 Products Division

The Products Division (PD) will be responsible for
product development support and delivery. The primary product
of PD will be an advanced support environment, however any
tool integrated in the environment could itself be treated
as a product that could be integrated by the Service with any
KAPSE-based (Kernal APSE) environment. Standalone products —
techniques or tools - also may be offered by PD.

The product repertoire of the SEI will be redefined
periodically in a product planning process. Product planning
will be a subactivity of the SEI strategic planning process.
The objective of the product planning activity will be to
balance the ORD project activities with the pressing software

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engineering needs of the DoD community. To accomplish this, three things are needed. First, PD must be continually evaluating the problems facing DoD software development groups to identify areas where new tools can improve productivity or reliability. Second, support environment enhancements and new standalone products which will address the needs must be identified. Third, the ORD project plan must be influenced to ensure that the needed technology is packaged and integrated. The PD product plan, then, will be a result of both demand pull and supply push. That is, both the needs of the users as identified by PD and the availability of promising technology, as identified by RD will govern the product packaging and integration projects of ORD. These in turn will feed the new product releases of PD.

The PD products will be controlled under a strict configuration management system. Products will be managed in releases. At least two releases will be under configuration control for every product that has been fielded - the fielded release and the next release under product development.

Before a release of a product will be issued it will undergo a product test and quality assurance (QA) process. The QA process will ensure that the product meets SEI standards for programming, documentation, and human engineering. Product test will ensure the correctness and reliability of the release.

An important function of PD will be customer relations and support. PD personnel will work in support of and, in some cases, on behalf of the Services in generating interest and demand for new software engineering tools and techniques in the end-user community. The PD personnel will also provide field support for installation, conversion, and training.

The primary training provided by PD will be courses offered at the Institute for the ECR Service organization personnel responsible for Service Environment support. These courses will be timed to coincide with new product releases of the SEI. They will instruct the Service representatives on the installation, operation, and use of the products. The use instruction will include training on the proper application of associated software engineering methods. Under certain circumstances, the PD personnel will provide the training at Service or DoD contractor sites. This will usually occur when an SEI product is being installed for use at a major development or in-service support site.

3.4.4 Operations Division

The Operations Division (OD) primarily is responsible for the maintenance and operation of the SEI data processing services. OD will be capable of supporting a two-shift operation. OD personnel will be capable of system engineering and systems programming support to the other Divisions.

Another important function of OD is measurement data collection and reporting. OD will collect certain measurement data automatically, e.g. from project management status files, and others will be collected manually and be keyed into machine readable form. Measurement reports of various types will be produced periodically for SEI management from the data base.

The Operations Division also will manage a limited service bureau operation to support Services or DoD contractor organizations who wish to use the SEI resources in support of their projects. A development project office may, via a network, send to the Institute a large body of software to be "run through a tool" on the Institute's computer and the results sent back out.

Initially, the Institute will provide this service at no cost to Service-authorized projects. After the initial shake-down, the Institute will - for a fee - provide this service to Service-authorized projects. This service will help to keep the Institute current on the state of the practice in the ECR software community.

3.5 PERSONNEL

In order to accomplish the functions described in section 3.1, the Institute will be staffed with some of the best software people in the world.

There are two ways, at least, to attract the quality of software porfessionals needed - i.e., the very best. First,

allow them to do original and interesting research in a well-supported laboratory. Second, offer the chance to change the state-of-the-practice across a wide part of the field. The Institute will do both. The SEI will provide an environment which will attract researchers in government, industry, and academia. Some researchers will be offered visiting positions of one to two years duration to evaluate, package, and integrate technology developed under his or her previous research efforts.

To be successful, a broad range of skills will be required in the Institute. Skilled researchers, administrators, product managers, development personnel, educators, and public relations personnel are just some of the diverse skills required. The skills and experience required for the key positions are summarized below.

a. Technical Director - The technical director will be responsible for the overall management of the SEI including planning, technical direction, financial management, and hiring. This will require sound skills in business management and experience in operating a $5-10 million enterprise. The technical director snould have experience in managing applied research. He should be familliar with the structure and management procedures of DoD. A PhD. in a computer-related discipline is desirable.

b. Administrative Manager - The administrative manager (chief of staff) will report to the technical director. He will be responsible for all administrative activities.

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He must be a skilled manager with experience in finance, contracts, personnel, public relations, and office management. His educational background should include an MBA.

c. Planning Specialists - The planning specialists will report to the technical director. They will be responsible for coordinating the SEI strategic and operations planning process. They must be experienced planners familiar with software technology and financial analysis. They must be familiar with the operation of software product businesses. Technical degrees are required.

d. Research Division Manager - The RD manager will report to the technical director. He will be responsible for the manning, planning inputs, and direction of RD. He must be an experienced manager knowledgeable in the field of software engineering technology. He should be a Ph.D. in computer sciences with strong connections in the world of software engineering R&D.

e. Outreach Division Manager - The ORD manager will report to the technical director. He will be responsible for the manning, planning inputs, and direction of ORD. In particular, he will be responsible for recruiting the visiting scientists who will lead the ORD projects. He must be an experienced manager with strong background in the management of applied research projects. He should be a technologist who can command the respect of visiting scientists.

f. Outreach Project Leaders - The leaders of ORD projects will report to the ORD manager. They will have responsibility for the management and technical direction of their projects. Since not all lead scientists are expected to be capable project managers, professional project management support will be available from the ORD permanent staff. The project leader must be a leader in the technology area which is the focus of his project.

g. Products Division Manager - The PD manager will report to the technical director. He will be responsible for the manning, planning inputs, and direction of PD. He must be an experienced manager who understands software product development, test, and marketing.

h. Product Development Manager - The product development manager will report to the Products Division manager. He will be responsible for the product packaging of ORD project technologies and for the support of the SEI support environment and fielded tools. He must have a solid background in software product development and support.

i. Product Test Manager - The product test manager will report to the Product Division Manager. He will be responsible for the testing of product releases before delivery to the Services. He must have a solid background in software product testing.

j. Product Distribution Manager - The product distribu-
tion manager will report to the Products Division Manager. He
will be responsible for the "marketing", delivery, installation,
and training support. The "marketing" responsibility will be one
of providing support to or acting on the behalf of the Services
in advertising the benefits of the available products and in
demonstrating the application of the products. The distribution
manager should be very knowledgeable of the DoD software community
and experienced in sales and field support.

k. Operations Division Manager - The OD manager will report
to the technical director. He will be responsible for the manning,
planning inputs, and direction of OD. He must be experienced in
the management of data centers supporting product development and
research projects.

4.0 ISSUES AND ALTERNATIVES

There are several difficult issues in regard to the creation of Software Engineering Institute. Some of these issues are:

a. What is the scope of the support base for the Institute? Should it be directed to the DoD community alone or should it be broad, encompassing the needs of other government agencies and industry?

b. How should the Institute be managed? Should it be managed at the Office of Secretary of Defense level, by a Triservice group, or by an industry/government consortium?

c. What should be the host organization mechanism? Should it be hosted in the government, industry, or academia?

d. What should the relationship be with STARS? Should the Institute perform some of the STARS research?

These questions are key to the successful establishment and operation of the Institute. The following sections discuss these issues in more depth. Alternatives are presented and evaluated.

4.1 SUPPORT BASE

The scope of the DoD support base is a key issue in that it determines the management approach and the very nature of the Institute. If the support base is limited to DoD and its contractors, then it is natural for the Institute to be managed by DoD and its products will be oriented to embedded

computer systems. If the support base is broad, including DoD, other government agencies, and industry, then the management of the Institute should represent the interests of all three and its products should address the broad range of problems associated with software of all types.

There are several alternative definitions of the Institute support base. One is to focus on the embedded computer systems sub-community of the DoD community. This sub-community is of vital concern to our national defense due to the importance of embedded computer systems to modern weapon systems. The Institute must serve this group at the least. Another alternative is to direct the Institute to the support of all government groups. The broadest alternative would direct the Institute to the support of government and industry.

Four considerations are important in evaluating the alternatives for the support base. One is the difference between embedded computer software and other software. The second is the focus of current industry activities in software technology. The third is the differing resource levels required for each alternative. The fourth is the degree of assurance that DoD's strategic needs will be satisfied.

Embedded computer software is a unique class of software system problem demanding a level of engineering discipline and management not reequired by other classes of software. These

large, real-time, complex systems require a different level of
tooling and project structure than that required for business
appplications. To date, engineering technology research has
not been directed to the solution of problems faced within this
class of software system. For this reason, it is imperative
that the Institute assure the application of sufficient resources
to this class of software as its first priority.

Most of the technology development in industry is aimed at
the commercial computer applications. Because embedded computer
systems are a small fraction of this marketplace, little emphasis
is being placed on them. On the other hand, it would be a waste
of resources for the Institute to focus on the predominant
commercial application classes since this would duplicate the
efforts of industry which has adequate impetus from market forces.

There will be a tremendous difference in the resource
requirements of the Institute depending on the support base
alternatives chosen. It would be a challenge to successfully
integrate and transition technology in the relatively narrow
DoD embedded computer sub-community. Here the scope of technology
can be defined and the channels for technology transition are
circumscribed. For the broad case of all government, or
government and industry, the technology integration would address
all classes of software and the technology transition channels
would be unmanageably large. It is unlikely that the difficult
goal of accelerated technology transition can be accomplished
in the broader contexts.

Given the breadth of software systems and the diverse
nature of software production in government and industry, it is
unlikely that the critical needs of DoD in the embedded computer
arena will get the necessary attention if the Institute addresses
all of government or government and industry as its support
base. Unless the Institute's resources are focused exclusively
on the difficult problems of embedded computers, the efforts of
the Institute will gravitate to the more manageable problems
characterizing commercial applications.

Based on the foregoing considerations, the following
conclusions are drawn:

a. The support base for the Institute should be limited
to the embedded computer system sub-community of DoD.

b. Advantage should be taken of the technology innovations
of industry in non-embedded applications by scaling it up.

c. The advances offered by the Institute, although targeted
to DoD, should be made available to other governmwent agencies
and industry.

By focusing the Institute on the DoD embedded systems sub-
community, the strategic needs of DoD will be satisfied. Because
embedded systems represent the most complex of software systems,
technology developed to support them will provide leading-edge
spin-off into other classes of software much as the technology
used for manned spaceflight has found its way into the home.
The Institute products will be useful to other Government agencies,
FAA, NASA, etc, who have embedded computer systems.

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4.2 MANAGEMENT

The management control of the Software Engineering
Institute must be assigned such that the objectives of the
Institute will be met. The decision on where to assign
the management responsibility is determined to some degree by
the support base decision. If the support base is all of
government and industry, then a government/industry consortium
might be the best approach. If the support base is primarily
DoD, the the management of the Institute should reside within
DoD.

In section 4.1 it was argued that the Institute should
support the embedded computer sub-community of DoD. This
suggests that the management of the Institute should be with
DoD. Two alternatives seem reasonable. One is to manage the
Institute at the level of OSD through the STARS Joint Program
Office. This alternative is described in the remainder of this
section. The alternative is to delegate the management to a
Tri-Service group. This alternative is described in Section 5.

To ensure coordination with the STARS program, the funding
for the group should flow through the STARS Joint Program Office
in coordination with the STARS Revire Committee (which is
composed of the STARS Director, the SEI Coordinator and the
three Service Program Managers). It also will be valuable to

include other government, industry, and academic guidance in the management of the Institute. This can be accomplished through a senior board of visitors. In addition, a technical interest group composed of DoD laboratory personnel and Service ECS environment users would provide advice to the management.

The major components and relationships regarding the management of the Institute are shown in Figure 5. The CSS, under DUSD (R&AT) will have DoD responsibility for STARS and the Software Engineering Institute. The STARS Review Committee will manage the SEI in a programmatic sense, setting objectives, controlling funding, approving budgets, and reviewing results. The SEI coordinator will manage the SEI Contract and provide the essential interface. The board of visitors will review technical plans and accomplishments of the Institute. It will make recommendations to the STARS Review Committee regarding technical direction of the Institute. The Service laboratories and environment users will have a close relationship with the Institute through the technical interest group. This relationship may include joint projects personnel exchange, and planned information exchange.
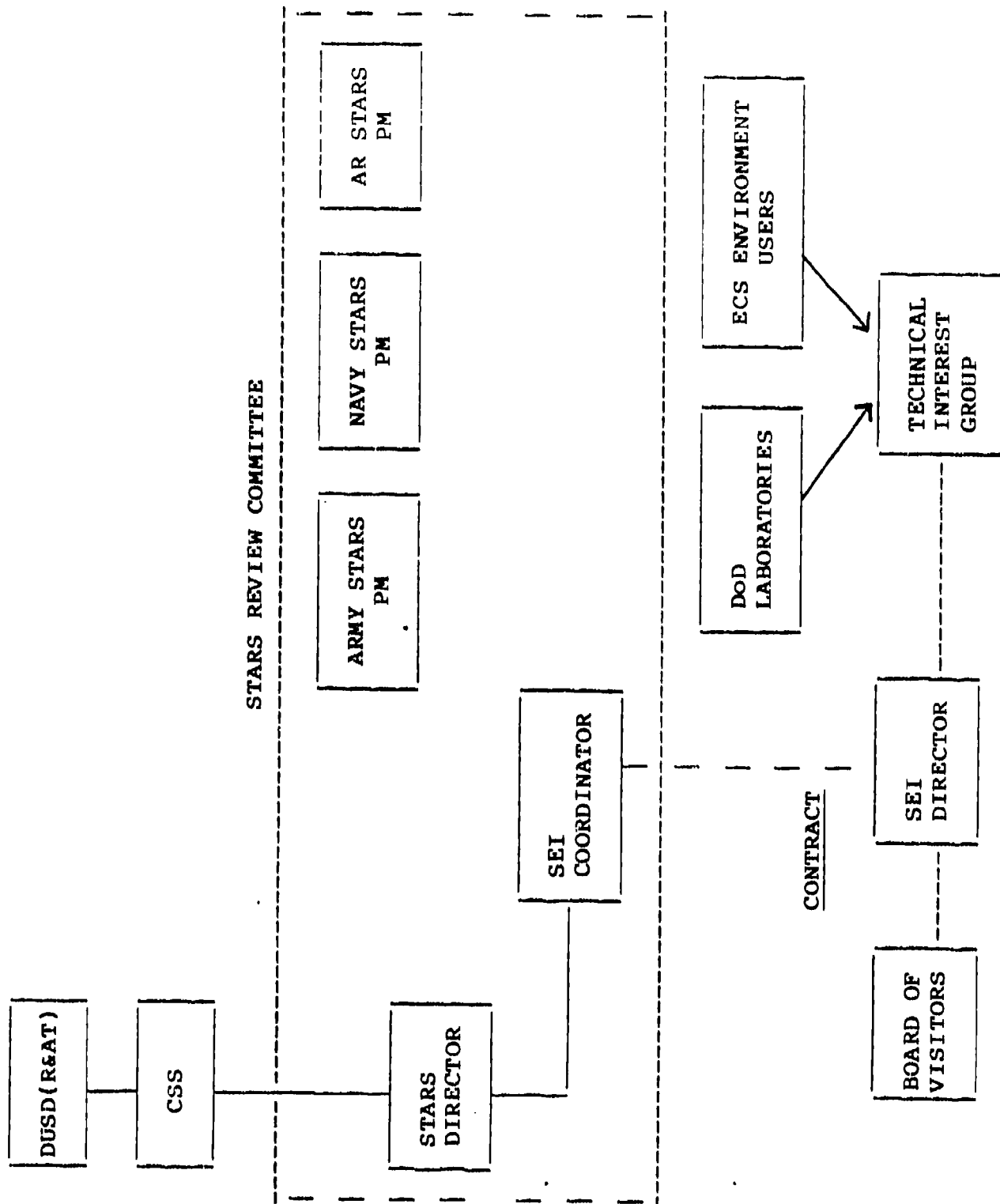
Figure 5: SEI Management and Relationships

4.3 HOST ORGANIZATION

Where to host the Institute is a difficult question, because there are many reasonable alternatives. The choice will depend on a number of factors which bear on the success of the Institute.

The alternatives considered are to delegate the responsibility to a Service, to set up an internal DoD program office, to contract with a private corporation to perform the responsibility, to establish the Institute in a Univeristy setting, or to set up or contract with a non-profit corporation.

The chief criteria used to differentiate the alternatives, in the order of decreasing importance, were the following:

a. DoD Needs - will the ECR system needs of DoD and the resultant software technology tools get first priority? This will be the case if the goals and incentives of the organization are fully directed to the needs of the DoD community. Any goals or incentives not so oriented may cause a confusion of aims in this very advanced area.

b. Effective Transition - will effective transition channels be established with the Services? Each Service has an established organizational structure including groups performing software technology research and transition. The SEI must create effective communications with the Services (and DoD contractors)

without duplicating the established organizations or confusing the flow of their effort.

c.   Personnel - will the best talent in the software engineering community be attracted? The SEI must provide an environment that is attractive to technologists and practitioners - good facilities, proximity to other technologists in the field, an atmosphere that rewards creativity and accomplishment, and a chance to make an impact.

d.   Cooperation - will the cooperation of government, industry, and academia be assured? The success of the SEI will depend on this cooperation as both a source and sink for new technology, and as a source of visiting scientists. The SEI must have the means to nurture this cooperation.

The Service alternative was rejected because it is unlikely that one Service will integrate and package technology in a manner generally useable by all the Services. Also, the existing shortage of software engineering professionals in the Services would be further aggravated by the responsibility to man an Institute. It is unlikely that the top people in the software engineering community can be attracted to a Service run operation of this type. The same general logic applies to the DoD program office alternatives.

A contract with a private corporation was rejected on a possible confusion of aims, rights to the products and a perceived conflict of interest or unfair advantage in future competitions. It is not felt that an entity driven by the incentives of the marketplace will consistently place the needs of DoD in a position of number one priority.

Both a University-based Institute and a non-profit organization are deemed suitable for the SEI. The University-based Institute is attractive because it offers a desirable atmosphere for technologists, thus enhancing the ability to attract first-rate visiting scientists. The proximity to an educational institution also may help support the training role of the SEI.

A University seems to promise a good magnet for the top people in the field and a good teaching facility. It would be natural to expand into a wider training role. The Institute must be free standing and not become encumbered by University politics, tenure practices, or "publish or perish" practices.

Despite these advantages of a University, the non-profit corporation perhaps teamed with a University or Universities is favored because of its strength in the principal activity of the Institute, namely transition. The role of software engineering technology packaging with product quality, the long term support of these products, and their distribution are not familiar activities of a Univerisity where the orientation is more in the realm of research-quality tools.

4.4 DISTRIBUTION OF THE INSTITUTE

The discussion in the previous sections have centered on an Institute operation where all the resources of the Institute are colocated. An alternative to this is the geographic distribution of resources. The advantages of distributing the Institute is to provide better locality to the pool of professionals from where the Institute will be manned and to be more responsive to the community the Institute will serve. The disadvantages are increased costs of communication and potential dilution of already scarce human resources.

There are several parts of the Institute that can be separated and distributed without difficulty. The activities of the Research Division are such that it can be separated from the rest of the Insititute as long as its products, e.g. surveys of on-going research, are readily available to the remainder of the Institute. This can be accomplished via telecommunications. The projects of the Outreach Division are good candidates for distribution.

This may be a necessity if the Institute is to get the cooperation of the top people as visiting scientists. Product installation and training support teams will be more effective if they are geographically close to the DoD groups they serve.

The product development and test resources should not be split up. To get the most out of the resources they must be concentrated about the activity of advanced software engineering

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environment support and integration of new tools with this environment.

The above discussion suggests a configuration for a distributed Institute consisting of three types of centers - product center, regional centers, and local projects. The product center, which may serve also as a regional center, will house the resources required to package, integrate, and distribute the Institute products. The regional centers will support project activities of Outreach and the product installation and training groups. Local projects might reside wherever the key professionals are located, e.g. Universities, Industry, or the Services.

The research division and the Institute management and administrative staff might reside at the product center or a regional center. The operations division would support the product center and the regional centers.

In order for such a distributed organization to function effectively, the data processing resources of the Institute should be distributed in the product center and the regional centers. A communications network would link the centers together. Local projects would access the Institute DP resources over telecommunications facilites as well as access to a local network of computing facilities.

Whether the Institute is created in a centralized or distributed organizational configuration it will have to support some form of distributed activity. The Institute's product-end-user is widely spread geographically. Effective distribution of the products will require on-site support. Certain Outreach projects will be performed where the key professional is located. Furthermore, making the Institute resources available on a pay-for-service basis implies remote access of DP facilities. Therefore, even in the case of centralized resources, distributed activities must be supported effectively.

5.0 EXPANDED SEI MISSION AND MANAGEMENT ROLE

The Institute is part of the STARS program, yet it is to
be operated and managed separate from the STARS research projects.
This has led to the Institute's mission description as defined
in section 3. An alternative approach is to further integrate the
Institute with STARS in such a way that the Institute manages
some or all of the STARS research areas. Although this alternative
would not necessarily alter the alternative choices made in the
previous sections it would add some complexity to these issues.

Service managers have expressed the desire for more Service
involvement in the proposed management of the STARS Program and of
the Software Engineering Institute. Tri-Service, joint-Service,
lead-Service, etc., schemes ve been suggested informally.

This section offers an alternative to combine the management
of the central focus of the STARS Program with the management of
the Software Engineering Institute. A joint DOD/tri-Service
management similar to that of the DOD Electromagnetic Compatibility
Analysis Center is presented.

5.1 Background

The STARS Program plan central thrust is the engineering
development of modern software development environments. These
efforts are to be based on available technology and provide near-
term advanced environments with respect to those in current use.

Additionally, the environments are to be able to accept new elements and tools. The Ada support tools (of the ALS and AIE) are to be integrated. These STARS projects are to be distributed among individual component organizations.

The Software Engineering Institute has a primary function to maintain an advanced Software Development Environment. Its primary function is to engineer new technology to continuously improve this environment and provide these new tools to Defense software developers. As the Institute comes into existence (presumably under contract), a question will arise as to the source of its "first model" advanced environment. If the STARS Program environment projects are successful, capabilities from one or more will be available for the Institute.

Since the Institute is to maintain an evolving advanced environment, it is appropriate to consider its role in the development of the STARS advanced environments. Thus, in addition to the mission as described in section 3, it is recommended that the SEI assume technical management and coordination of the STARS Program core projects, namely to develop modern software life-cycle engineering environments.

5.2 Organization of the Expanded Software Engineering Institute

The expanded mission of the Institute will require a resident cadre of DoD technical managers. Figure 6 shows an organization

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                        ┌─────────────────────────┐
                        │           DoD           │
                        │   Software Engineering   │
                        │        Institute        │
                        │     Contract Manager     │
                        └─────────────────────────┘
                                     │
      ┌───────┬────────┬─────────────┼──────────┬───────────┐
  ┌───────┐ ┌───────┐ ┌──────────┐   │   ┌──────────┐ ┌──────────┐
  │ Army  │ │ Navy  │ │Air Force │   │   │  Plans   │ │ Support  │
  │Deputy │ │Deputy │ │ Deputy   │   │   │  Office  │ │ Office   │
  └───────┘ └───────┘ └──────────┘   │   └──────────┘ └──────────┘
                                  CONTRACT
                                     │
                        ┌─────────────────────────┐
                        │        Director          │
                        │  Software Engineering    │
                        │       Institute          │
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                                     │
  ┌──────────────────┐                         ┌──────────────────┐
  │  Administrative  │                         │    Technical     │
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  └──────────────────┘             │           └──────────────────┘
                                   │
      ┌───────────┬────────────────┴──────────┬────────────┐
  ┌──────────┐ ┌──────────┐           ┌──────────┐ ┌──────────┐
  │ Research │ │ Outreach │           │ Product  │ │Operations│
  │ Division │ │ Division │           │ Division │ │ Division │
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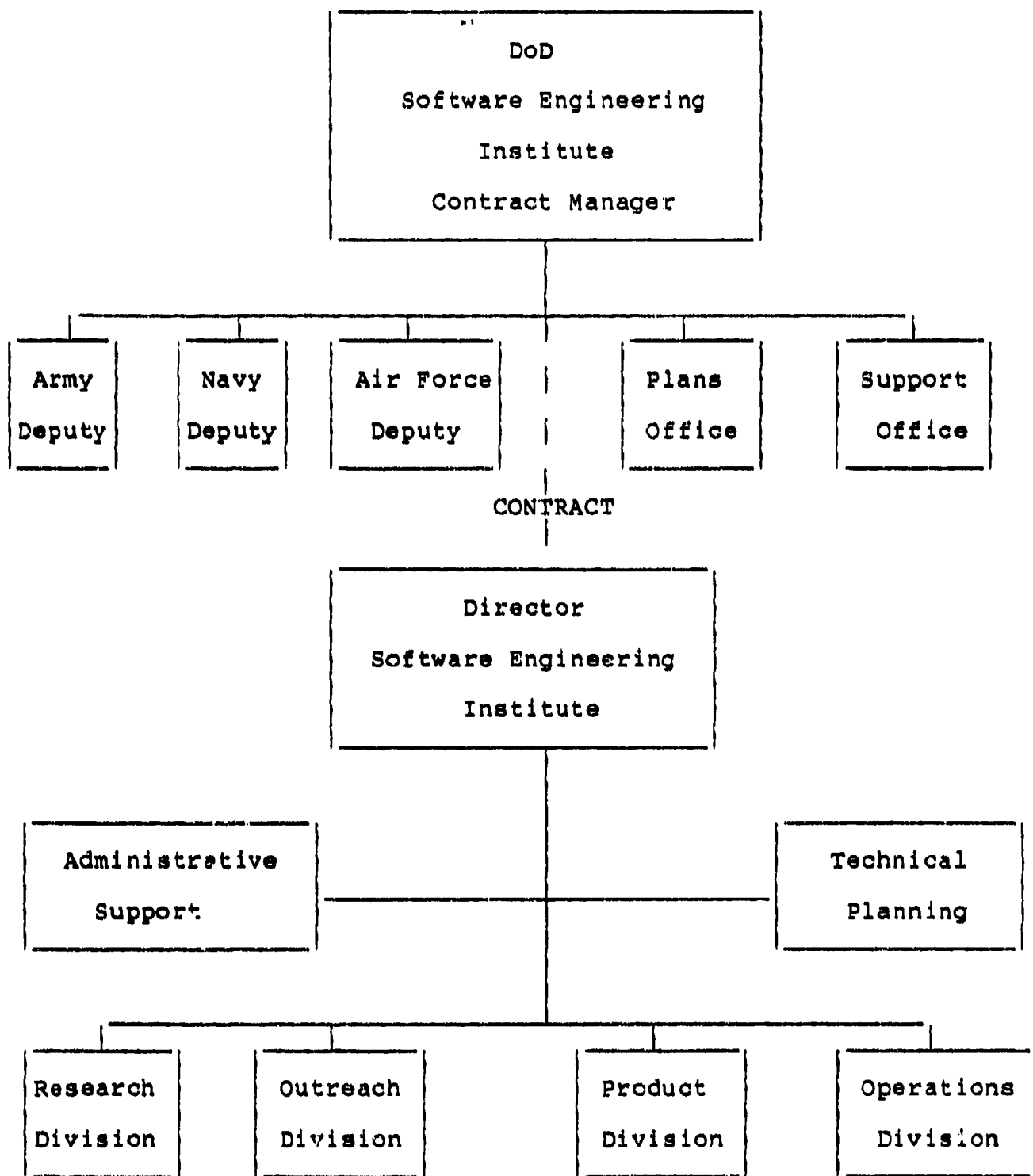
Figure 6: SEI Expanded-Mission Organization

structure which could support the expanded SEI functions. This
structure is modelled after the Electromagnetic Compatibility
Analysis Center (ECAC), which is summarized in section 5.5.
Resident members of the three Services form a DoD component of
the SEI to manage both the on-site and off-site contracted
efforts. Army, Navy and Air Force deputy directors and their
assistants are responsible for research and development projects,
initially for the development of an advanced software development
environment, later for environment metrics research and integration
research.

The Service deputies assist the director in managing the
on-site SEI contractor. They provide liaision with the Services
assuring proper interface is maintained with the appropriate
Service elements. They assure that their Services' needs are
considered in the Institute's planning and programming. They
are active agents in the understanding of the state-of-the-practice
shortcomings and needs, and in matching technology state-of-the-
art to these needs. They are influential in the transitioning
of technology to the institute and in the insertion of Institute
engineered and integrated tools into the Defense community.

The DoD component of the Institute has a vital role in
"selling" the new products of the Institute. Since they are
involved in evaluating and understanding the Service community
needs, each representative will be uniquely able to assist
in the insertion of new tools which have been engineered by the
Institute to meet his Service's needs.

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The contractor component of the SEI organization is essentially the same as described previously. Its functions are unchanged.

5.3 Management Relationships

From the DoD point of view, the participation in real time and closer control and feedback is clearly an advantage. The DoD and contractor components work together in planning and in executing the SEI mission activities. The resident Service personnel provide a credible communication link to each of the Services.

From the contractor's view, the close proximity of DoD management may be perceived both positively and negatively. Certainly the assistance in liaision with the Defense community is a positive factor. The closer control exercised may well be a mutual advantage, rather than one accruing only to the Government.

5.4 The DoD Electromagnetic Compatibility and Analysis Center

The DOD Electromagnetic Compatibility Analysis Center (ECAC) was established in 1960 as part of the DOD electromagnetic compatibility (EMC) program wherein the Army, Navy, and the Air Force were assigned specific responsibilities. The Air Force was assigned the responsibilty as executive agent for the management of ECAC.

The joint-service operated Institute receives general guidance and direction and is situated within the Department of Defense as illustrated in Figure 7. Broad policy and guidance is provided by the Chairman Joint Chiefs of Staff and the Assistance Secretary of Defense for Research and Engineering, or their designees. Plans for the development and operation of ECAC are subject of their approval.

A DoD Directive prescribes the mission, functions and responsiblities and operational relationships and management arrangements. As specified by the directive, the ECAC functions administratively under the direction of the Secretary of the Air Force. Early DoD manning of ECAC came from all three Services. Currently, it is staffed by Air Force personnel.

ECAC is the DOD focal point for the development of EMC analytical capabilities. ECAC provides advice and assistance on EMC matters to the Secretary of Defense, the Joint Chiefs of Staff, the Military Departments, and other DOD components. Engineering support services are provided to ECAC by a contractor. The government-contractor team provides an unequaled technical resource to deal with the myriad EMC tasks confronting the Department of Defense.

The Assistant Secretary of Defense (Telecommunications) and the Chairman, Joint Chiefs of Staff or their designees jointly provide policy guidance, assign projects, and establish projects
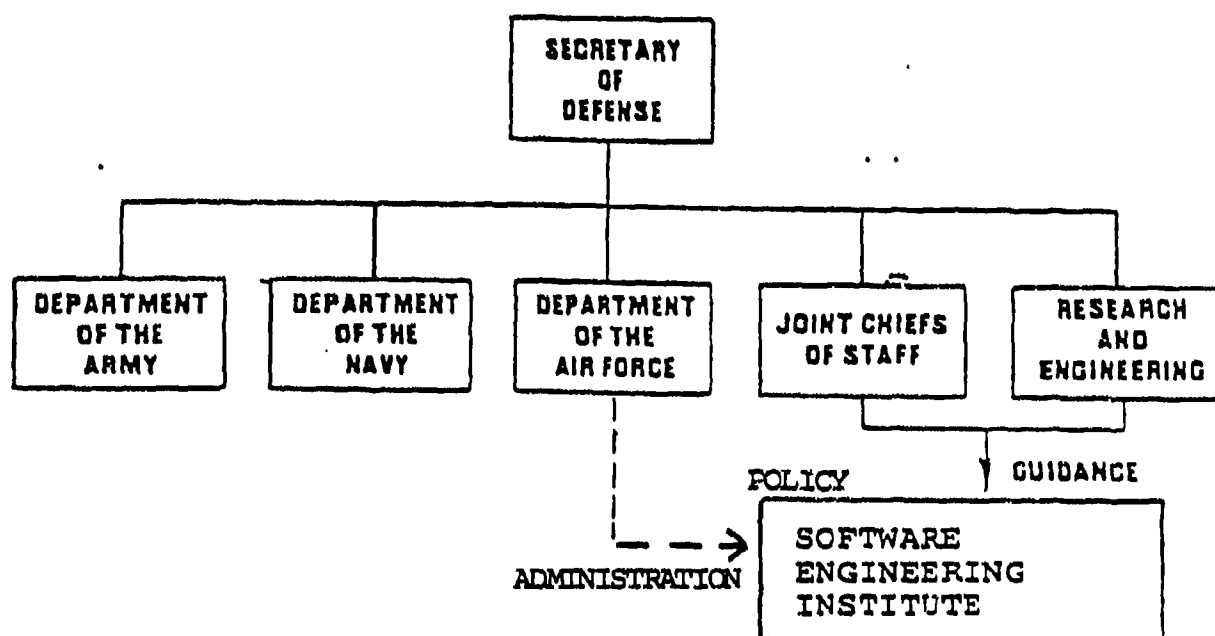
Figure 7. ECAC Management

priorities. Plans for the development and operation of the ECAC are subject to their approval.

DOD Directive 5160.57 prescribes the mission, functions, responsibilities, operational relationships, and the management arrangement for the joint DOD Electromagnitic Compatibility Analysis Center (ECAC).

If the SEI were to be modelled after ECAC, administrative responsibility would be delegated to one of the Services. The Director could be an 0-6, rotated among the Services.

6.0 IMPLEMENTATION PLAN

Irrespective of the alternatives chosen, as discussed in Sections 4 and 5, the SEI should have a minumum life of 10 years. This will allow for the effective integration and delivery of any technology flowing from the five year STARS program. The SEI may be continued beyond 10 years if a need is perceived.

The SEI will be funded under a multi-year contract with options. The initial contract will be competed. University and non-profit corporations will be encouraged to participate. Successfull performance by the winner will assure a 5 or more year period. of performance before recompetition. Poor performance would result in cancellation of the options years and a recompetition after 3 years.

The overall operation of the SEI will be evaluated continually by DoD for effectiveness. The evaluation will be supported by performance measures. The performance measures will be used to compare results to objectives and the stategic operating plan.

It will take several years from its inception for the SEI to reach full operating capacity. A start-up strategy for this phase is presented in section 6.1. The personnel resources and facility requirements are presented in 6.2. An estimate of the costs for the first five years of operation is presented in section 6.3.

6.1 START-UP STRATEGY

It will take several years to reach the steady state
operations of the SEI described in Section 3 of this plan. A
start-up plan describes how the SEI will reach steady state
operations. The start-up plan does not address the activities
required to award a contract for SEI operations. These
activities are summarized in Figure 8 which assumes an October
1983 contract initiation. It is recognized that this is an
optimistic milestone, but until a more realistic date can be
decided upon, this date will be used since it provides for fiscal
year alignment of the start-up plan phases with the fiscal year
budget given in Section 5.3. The remainder of this section
describes the phases the SEI will pass through following contract
award to the hosting agent. This plan is not affected significantly
by the DoD management alternative chosen. It addresses the host
agent activities, only.

The SEI life cycle operation can be viewed in four
phases: initiation, pilot operation, expansion, and steady
state. The first three of these phases are the subject of
the start-up plan. Figure 9 shows the major activities asso-
ciated with the three start-up phases. Each of the three
phases will last one year. After three years, steady state
operations will be attained.

6.1.1 Initiation Phase

The initiation phase will establish the basic elements
required for SEI operations. These elements are:

ACTIVITY	F	M	A	M	J	J	A	J
Business plan approach	▽							
RFP Preparation		├──────┤						
RFP Approval			├─┤					
RFP Issue				▽				
Proposal preparation				├──────────┤				
Proposal Submission							▽	
Proposal Evaluation							├───┤	
Contractor Selection								▽
Negotiation								├─┤
Contract Start								▽
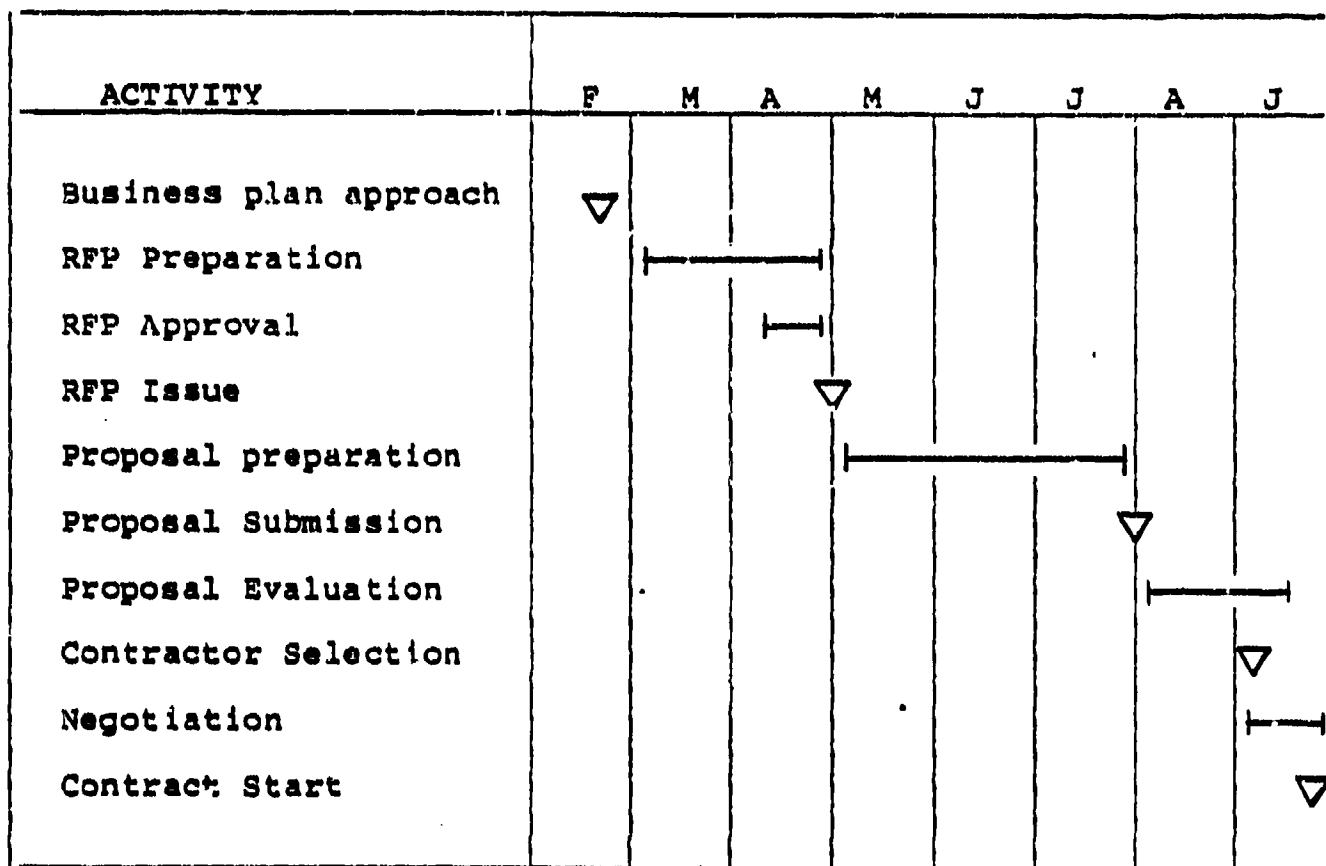
Figure 8: SEI Acquisition Plan

CONTRACT

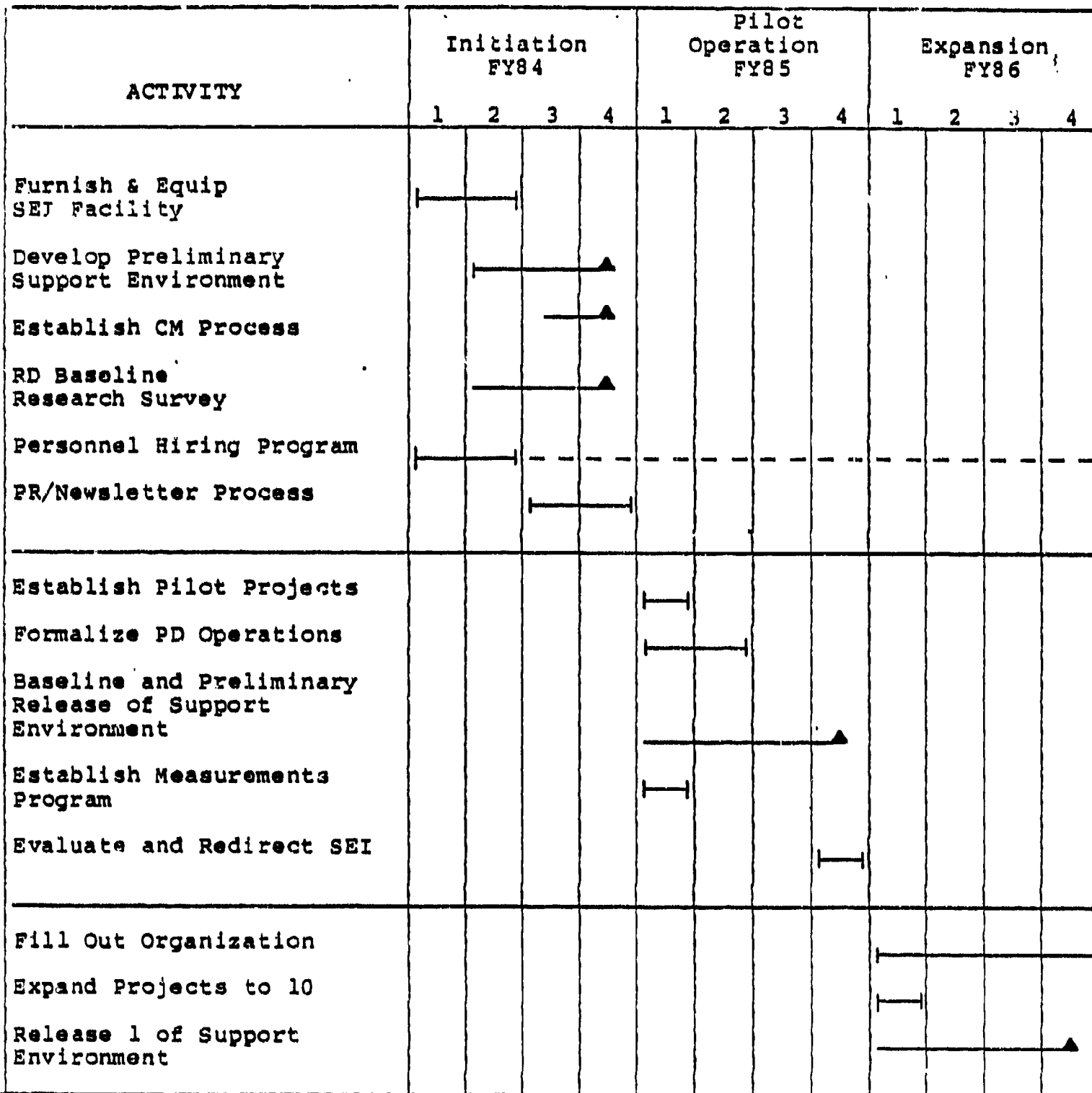| ACTIVITY	Initiation FY84				Pilot Operation FY85				Expansion FY86			
	1	2	3	4	1	2	3	4	1	2	3	4
Furnish & Equip SEI Facility	├──┤											
Develop Preliminary Support Environment		├──────▲										
Establish CM Process			├──▲									
RD Baseline Research Survey		├─────▲										
Personnel Hiring Program	├──┤ ─											
PR/Newsletter Process			├──┤								
Establish Pilot Projects					├─┤						
Formalize PD Operations					├──┤						
Baseline and Preliminary Release of Support Environment					├───────▲						
Establish Measurements Program					├─┤						
Evaluate and Redirect SEI								├─┤			
Fill Out Organization									├──────┤		
Expand Projects to 10									├─┤		
Release 1 of Support Environment									├──────▲		

Figure 9: Start-up Plan Phases

a. Facilities - the SEI offices, computer center, and computer laboratories will be furnished and equipped to a level sufficient for pilot operations.

b. Preliminary support environment - Using an advanced release version of MAPSE, an operational environment will be brought up and stabilized at the SEI computer center. Proper channels will be established for the continued coordination of MAPSE releases to the SEI.

c. Product Definition and Configuration Management Process - The management process and supporting tools whereby the support environment enhancements will be approved, integrated, and released will be defined.

d. Baseline Research Survey - A baseline survey of research in software engineering will be produced by RD to serve as the basis for continuing RD activity and to select pilot projects.

e. Personnel Hiring Program - the Administrative group responsible for personnel will be established. They will create the mechanisms and contacts necessary to hire the SEI permanent staff and to keep a continuing stream of visiting scientists pumping through the SEI.

f. Public Relations and SEI Newsletter - The Admini-
    strative group responsible for public relations
    will be established to set up lines of communication
    with the software community.

6.1.2 Pilot Operations Phase

The pilot operations phase will establish the operation
of the SEI in a skeletal form to evaluate the operational
concept and make appropriate changes prior to expansion to
full operation. The primary activities initiated in this
phase are:

a. Pilot Projects - Two to four pilot projects will
    be initiated by the Outreach Division. The pilot
    projects will be selected from the survey produced
    by RD during the initiation phase, and from a
    list of internal technology projects aimed at
    research into integration and transition tech-
    niques.

b. Product Division Operations - formally begin PD
    operations by setting into action the product
    definition and configuration management process.

c. Baseline support environment Trial Release - the
    preliminary support environment will be upgraded
    with the most current MAPSE pre-release. The
    release process will be exercised (without
    actually releasing a product) to iron out any
    problems.

d. Measurements Program - The SEI effectiveness
    measures will be implemented by the Operations
    Division and will be applied to the pilot operation.

e. Evaluation - the pilot operation will be evaluated.
    The main purpose of the evaluation will be to
    determine if the concept of operation is feasible
    based on the results of the pilot operation. The
    operations will be reshaped where appropriate
    before expanding to full operations.

6.1.3 Expansion Phase

The expansion phase will focus on the expansion of the SEI
to full manning, approximately 10 active projects, and
full Products Division operations. The primary activities
of this phase are:

a. Fill Out Organization - the SEI manning will be
    increased to the steady state manning.

b. Projects - The Outreach projects will be increased
    to as many as ten.

c. support environment - the first release of the ⌐ ⌐
    sponsored support environment will be delivered to
    the Services.

6.2   RESOURCE REQUIREMENTS

The primary resources required to operate the SEI are
people, buildings, and computer equipment. The SEI will be
manned with a permanent staff and visiting scientists.
Support contractors will be used as needed. Figures 10, 11,
and 12 show the manning growth of the SEI over the three
start-up phases culminating in a steady state manning of
116 (81 permanent and 35 visiting) at the end of the expansion
phase.

The SEI will be located in a University of a non-profit
corporation setting. Office and laboratory space will be
provided along with the necessary equipment to support the
evaluation, integration, and delivery of software engineering
technology.

ORGANIZATION	Manning							
	Total		Mgt. & Prof.		Cler./ Tech.		Visit. Sci.	
	AVG.	YE	AVG.	YE	AVG.	YE	AVG.	YE
Office of Director	3	3	2	2	1	1	0	0
Administrative Support	4	7	3	4	1	3	0	0
Planning	1	1	1	1	0	0	0	0
Research Division	3	5	3	5	0	0	0	0
Outreach Division	1	1	1	1	0	0	0	0
Products Division	4	7	4	6	0	1	0	0
Operations Division	3	5	2	3	1	2	0	0
Total	19	29	16	22	3	7	0	0

Figure 10:   Initiation Phase Manning

ORGANIZATION	Manning							
	Total		Mgt.& Prof.		Cler./Tech.		Vis.Sci	
	AVG.	YE	AVG.	YE	AVG.	YE	AVG	YE
Office of Director	3	3	2	2	1	1	0	0
Administrative Support	10	13	5	7	5	6	0	0
Planning	2	2	2	2	0	0	0	0
Research Division	6	7	5	5	0	0	1	2
Outreach Division	10	16	2	3	1	1	7	12
Products Division	8	12	6	10	1	1	1	1
Operations Division	7	8	3	4	4	4	0	0
TOTAL	46	61	25	33	12	13	9	15

Figure 11: Pilot Operations Phase Manning

| ORGANIZATION | Manning | | | | | | | |
| | Total | | Mgt.& Prof. | | Cler./Tech. | | Vis.Sci | |
	AVG.	YE	AVG.	YE	AVG.	YE	AVG	YE
Office of Director	3	3	2	2	1	1	0	0
Administrative Support	12	13	5	5	7	8	0	0
Planning	2	2	2	2	0	0	0	0
Research Division	7	7	5	5	0	0	2	2
Outreach Division	30	40	6	8	2	2	22	30
Products Division	24	36	19	28	3	5	2	3
Operations Division	12	15	6	8	6	7	0	0
TOTAL	90	116	45	58	19	23	26	35

Figure 12:   Expansion Phase Manning

The office space for the Institution must be sufficient to support a minimum of 116 professionals and supporting clerical staff. At least 14,000 square feet of office space will be required. Space for a central computer complex, terminals, and five computer laboratories also will be required. Another 2,000 square feet will service this need. The office and laboratory space should be colocated for ease of access and communications among the Institute staff.

The offices will be equipped initially with desks, chairs, file cabinets, etc. to support the professional activities. Office automation equipment including word processors, copiers, and facsimile devices will be provided. At least 70 terminals and workstations will be required to support the day-to-day activities for the professional staff. A local area network may be used to provide interconnection.

A central computer complex consisting of a configuration suitable for the support of a large support environment operation will be provided. This complex will be capable of supporting the 70 terminals in a time-sharing environment, connection, and dial-up teleprocessing. A variety of mini and microcomputers may be used in the computer laboratories.

The central computer resources will be tied to the outside world via the ARPANET and dial-up lines. High speed communications lines also may be desirable for direct transimission of support environment releases to the Services.

6.3 FINANCIAL PLAN

The financial plan for the first five years of SEI operation is shown in Figure 13. The figures do not include the cost of the acquisition activities summarized in Section 5.1, Figure 8. The budgets for all five years are expressed in 1984 dollars. All facilities and capital equipment are budgeted on a lease basis.

The salaries are estimated using the manning levels shown in Figures 10, 11, and 12. The average annual salaries for each labor category were assumed to be as follows:

	Average Base	w/Fringe
Permanent professional	$ 60,000	69,000
Visiting professional	50,000	57,500
Technical/clerical	20,000	23,000

These salaries are increased by 15% to account for fringe benefits (insurance, FICA, disability) before computing the salary budgets. Further, it is assumed that the salaries of 50% of the visiting professionals are paid by their sponsoring organizations.

The overhead includes utilities, telephone, supplies, travel, conferences, accounting services, etc. A flat rate of 20% of salaries is assumed. Since overhead expense will be incurred on all staff, the salaries of those visiting professionals sponsored by their employers are included (i.e. visiting professional salaries shown in Figure 13 are doubled before computing overhead).

Budget Item	BUDGETS					
	YR 1	YR 2	YR 3	YR 4	YR 5	TOTAL
Salaries						
Permanent Professional	1,104	1,724	2,760	3,312	3,312	12,212
Visiting Professional	0	259	633	1,006	1,006	2,904
Tech./Clerical Support	70	280	443	513	513	1,819
Overhead	235	504	894	1,167	1,167	3,967
Facilities	75	165	240	240	240	960
Capital Equipment						
Central Computer Complex	200	400	500	500	500	2,100
Computer Laboratories		100	200	200	200	700
Office Equipment & Terminals	91	221	408	504	504	1,728
Support Contractors	400	1,000	1,600	2,000	2,000	7,000
TOTAL	2,175	4,653	7,678	9,442	9,442	33,390

Figure 13: SEI 5-Year Financial Plan

The facilities costs are computed assuming an annual cost of $15 per square foot. The space requirement for each of the five years is assumed to be:

FY84   :   5,000 square feet

FY85   :   11,000 square feet

FY86-88:   16,000 square feet

The capital equipment items are budgeted as leased equipment. The central computer complex includes computer(s), disks, tapes, printers, communications equipment, and other supporting equipment. Five hundred thousand dollars per year is budgeted for the fully configured complex. Equipment for the computer labs - microcomputers, graphics terminals, etc. - is estimated at a value of $500,000 or a lease cost of $200,000 per year. The average monthly cost of office furnishings per person is $100. In addition, $300 per month per person is assumed for terminals (computer timeshare, word processors, etc.).

Subcontractor support is assumed for specialty skills and load levelling of the SEI workload. One hundred thousand dollars per man year is assumed. The contract manning level assumed is shown below.

FY84   :   4

FY85   :   10

FY86   :   16

FY87-88:   20

APPENDIX

SOFTWARE ENGINEERING INSTITUTE
ISSUES AND ALTERNATIVES RAISED AT THE
STARS WORKSHOP, 7-9 Feb 83
TECHNOLOGY INSERTION PANEL

The following 13 areas received considerable attention by Panel members and
were addressed in open session comments at the Workshop. A brief description
of the issue and alternatives is given and a rationale provided for the Panel
consensus.

1.   Should the SEI focus its software engineering efforts on the embedded
computer applications area or to a broader scope of software development areas?

     Consensus: Embedded computer systems.

     Rationale: DOD embedded computer systems (ECS) are critical to our National
     defense posture. They stress the extremes of such system characteristics.
     Unlike the ADP application environment, where industries focus their R&D
     efforts, little industry effort is put on defense unique ECS applications.
     The DOD must focus its attention on this area. Industry R&D will satisfy
     most Defense ADP needs.

2.   Should the SEI provide products and services and foucs its attention to the
Defense community or to all areas and users of ECS?

     Consensus: The Defense community.

     Rationale: This question is related to the first. Because DOD resources
     are limited, the SEI should focus on defense needs. Non-sensitive spin-off
     technology will have commercial application and will be made available.

         The scope of the SEI mission and focus could be broadened, perhaps,
     with a larger basis of support from outside the DOD. This is discussed
     in #8 below.

3.   Should the SEI's primary mission be limited to engineering and integration
of software development technology or should it support and accomplish software
research as well?

     Consensus: The consensus favored including research in the SEI mission.

     Rationale: A significant portion of the SEI staff is to be made up of
     visiting researchers who will bring software research products to the
     Institute for engineering and integration into the Institute's software
     development environment. A strong research program will encourage this
     infusion of quality people.

         In addition, the Institute should do research on software development
     environment measurements and technology transition.

4.   Should the Institute be responsible for maintaining the DOD "standard"
software development environment for all services to use?

Consensus: No.

Rationale: Current Service policies separately address the standardization
of computer resources including development systems. As the Ada language
and programming support environments are developed, there will be a
convergence towards commonality.

The SEI will develop and maintain an advanced environment compatible
with the Ada programming environments developed by the Services. This
will assure the efficient transition of new tools from the Insititute to
the Services and their contractors.

5.   Should the Institute provide software engineering education and training?
A possible extension of the mission might be an extensive academic program, to
the possible extent of a degree granting institution.

Consensus: Education and training to support tool and practice transition
should be accomplished. Additional education in general software development
involving the SEI environment should be carried on. The training should
be provided to key Service and contractor personnel who would then provide
the education to larger groups of environment users.

Rationale: Broadening the scope of education would require greater SEI
resources than available. The Services have their undergraduate and
graduate programs as well as other training programs which should provide
for general needs.

6.   Should the SEI provide facilities and offer computer processing (including
software tools) resources and services for fee?

Consensus: It seemed appropriate that, at the beginning, only limited
services-for-fee should be provided. Such services involving the use of
new tools could be provided as a way of introducing these tools as well as
evaluating their effectiveness in real applications.

Rationale: A larger operation to provide complete environment and remote
computer service capability for the DOD community seemed very ambitious.
It could be an SEI growth possibility if its effectiveness and feasibility
is demonstrated by initial, smaller scale experiments.

7.   Are the scope, size, and budget, as proposed, compatible?

Consensus: The size and scope are compatible. The budget as proposed was
not adequate.

Rationale: The budgeted amounts for personnel were too small. (These
amounts have been increased in the current plan.)

8. Should the management and the support for the SEI be DOD based or broader based? Should other Government agencies, i.e., NASA, FAA, etc,. be included? Should organizations outside Government be involved in support and management of the SEI?

>   Consensus: Although strong suggestions for a "National" SEI were heard, the Panel recommended limiting management for the DOD. Support grants can be accepted from outside but not direction.

>   Rationale: The focus should be maintained to support the Defense community embedded computer software engineering area. Thus, management should be limited to the DOD.

9. How should the SEI be managed within the DOD -- by OSD, by the Services jointly, or by a single Service?

>   Consensus: The SEI is a part of the STARS Program and probably will remain part of this program as long as it exists. The STARS Program is currently planned as a joint-Service managed program, the management to be composed of Service representatives.

>   Rationale: The above was not throughly worked out. Strong Service views exist that the SEI, and possibly the STARS program as well, should be Service managed.

10. What vehicle or host institution should be used to organize and establish the SEI -- a university or university consortium, a not-for-profit company, a for-profit corporation, or a Service or Agency?

>   Consensus: The university, university consortium, or not-for-profit corporation were favored.

>   Rationale: The DOD is personnel resource limited. Establishing the SEI within the DOD would cause a personnel resource redistribution which would adversely effect other functions. DOD salary structure would limit the effectiveness in obtaining quality personnel.

>   The motivation of for-profit industry appears incompatible with the free interchange of ideas necessary for the SEI.

>   Some expressed the belief that researchers would be better attracted to university environment.

11. Orientation of the Institute -- user needs or technology push?

>   Consensus: User needs

>   Rationale: The requirements of software developers in industry and in Service centers must be the driver for the SEI activities.

12. Type of personnel required for the SEI mission — world-class researchers or other types?

Consensus: A variety of personnel will be required to staff a successful SEI, both engineering and research.

Rationale: A specific type of engineering resource is required to transition, engineer, and integrate software engineering tools and develop advanced environments. A thorough understanding of the application — software engineering of real systems — is needed. "World-class" researchers probably are not the best resource; however, these people must still be attracted to the Institute to bring in new ideas.

13. Name. Alternative names for the Institite were suggested and discussed. One in particular — "Software Engineering Technical Center" — was favored.

Consensus: There was no mandate to change the name.

Rationale: It is appropriately left until the mission and made of operation are determined.