

FY86 YEAR-END REPORT FOR
PROJECT 5720 — SOFTWARE CENTER GENERAL SUPPORT

By

JUDITH A. CLAPP

FEBRUARY 1987

Prepared for
DEPUTY COMMANDER FOR DEVELOPMENT PLANS AND SUPPORT SYSTEMS
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
Hanscom Air Force Base, Massachusetts



Approved for public release;
distribution unlimited.

Project No. 5720
Prepared by
THE MITRE CORPORATION
Bedford, Massachusetts
Contract No. F19628-86-C-0001

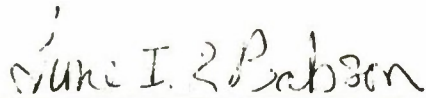
ADA178900

When U.S. Government drawings, specifications or other data are used for any purpose other than a definitely related government procurement operation, the government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Do not return this copy. Retain or destroy.

REVIEW AND APPROVAL

This technical report has been reviewed and is approved for publication.



JUNE I. R. BABSON, Major, USAF
Chief, ESD Software Center

FOR THE COMMANDER



ROBERT J. KENT
Director, Software Design Center
Deputy Commander for Development
Plans and Support Systems

REPORT DOCUMENTATION PAGE				
1a. REPORT SECURITY CLASSIFICATION Unclassified		1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited.		
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE		5. MONITORING ORGANIZATION REPORT NUMBER(S)		
4. PERFORMING ORGANIZATION REPORT NUMBER(S) MTR-10156 ESD-TR-87-128		7a. NAME OF MONITORING ORGANIZATION		
6a. NAME OF PERFORMING ORGANIZATION The MITRE Corporation	6b. OFFICE SYMBOL (if applicable)	7b. ADDRESS (City, State, and ZIP Code)		
6c. ADDRESS (City, State, and ZIP Code) Burlington Road Bedford, MA 01730		9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F19628-86-C-0001		
8a. NAME OF FUNDING / SPONSORING ORGANIZATION Deputy Commander for (cont.)	8b. OFFICE SYMBOL (if applicable) XRS2	10. SOURCE OF FUNDING NUMBERS		
8c. ADDRESS (City, State, and ZIP Code) Electronic Systems Division, AFSC Hanscom AFB, MA 01731-5000		PROGRAM ELEMENT NO	PROJECT NO 5720	TASK NO. WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification) FY86 YEAR-END REPORT FOR PROJECT 5720 - SOFTWARE CENTER GENERAL SUPPORT				
12. PERSONAL AUTHOR(S) Clapp, Judith A.				
13a. TYPE OF REPORT Final	13b. TIME COVERED FROM TO	14. DATE OF REPORT (Year, Month, Day) 1987 February	15. PAGE COUNT 31	
16. SUPPLEMENTARY NOTATION				
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	Software Acquisition Software Technology		
		Software Engineering Transition		
		Software Metrics		
19. ABSTRACT (Continue on reverse if necessary and identify by block number) This report summarizes the activities of Project 5720 in FY86. This project provides general software acquisition support to the ESD Software Design Center and to the MITRE Software Center. Its activities include implementing new acquisition policies, applying Software Reporting Metrics, using performance simulation and prototyping, introducing Ada, and supporting the transition of technology in Artificial Intelligence and Computer Security.				
20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION Unclassified		
22a. NAME OF RESPONSIBLE INDIVIDUAL Diana F. Arimento		22b. TELEPHONE (Include Area Code) (617)271-7454	22c. OFFICE SYMBOL Mail Stop D230	

UNCLASSIFIED

8a. Development Plans and Support Systems.

UNCLASSIFIED

ACKNOWLEDGMENT

The work and some of the words in this year-end report are the effort of over fifty people who contributed to Project 5720 in FY86. My role has been to integrate the diverse parts into a more complete picture of the project activities for this year. Any misrepresentations are undoubtedly mine.

This document has been prepared by The MITRE Corporation under Project No. 5720, Contract No. F19628-86-C-0001. The contract is sponsored by the Electronic Systems Division, Air Force Systems Command, United States Air Force, Hanscom Air Force Base, Massachusetts 01731-5000.

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1 BACKGROUND	1
1.0 INTRODUCTION	1
1.1 RATIONALE FOR THE SOFTWARE CENTER	1
1.2 GOALS OF THE SOFTWARE CENTER	1
1.3 GOALS OF PROJECT 5720 IN THE SOFTWARE CENTER	2
1.4 SCOPE OF ACTIVITIES OF THE SOFTWARE CENTER	2
1.4.1 Direct Acquisition Support	2
1.4.2 Short-Term Support	2
1.4.3 General Acquisition Support: Project 5720	4
1.4.4 Technology Transition: Project 5720	5
2 PROJECT 5720 FY86 ACCOMPLISHMENTS	6
2.0 INTRODUCTION	6
2.1 FY86 STAFFING AND FUNDING	6
2.2 GENERAL ACQUISITION SUPPORT	6
2.2.1 Policy Implementation	6
2.2.2 Software Reporting Metrics	7
2.2.3 User-System Interface Design	8
2.2.4 Simulation, Modeling, and Prototyping	9
2.2.4.1 Performance Modeling	9
2.2.4.2 Functional Simulation	10

<u>Section</u>	<u>Page</u>
2.2.4.3 Simulation and Modeling Day	11
2.2.4.4 Display Rapid Prototyping System	11
2.2.5 Information Collection and Dissemination	11
2.2.5.1 HelpLine	11
2.2.5.2 Newsletter	11
2.2.5.3 Software Acquisition Library	12
2.2.5.4 Courses, Seminars, and Symposia	12
2.2.5.5 Technical Interchange Meetings	13
2.2.5.6 ESD/MITRE Software Acquisition Symposium	13
2.3 TECHNOLOGY TRANSITION	15
2.3.1 Introduction of Ada at ESD	16
2.3.1.1 Acquisition Support	16
2.3.1.2 SAC Ada Development and Maintenance Study	17
2.3.1.3 Technology Application	17
2.3.2 Ada Joint Program Office Support	19
2.3.2.1 Prototype CAIS	19
2.3.2.2 CAIS Consultation	19
2.3.3 Ada Community Participation	19
2.3.4 Artificial Intelligence Applications	20
2.3.4.1 PE 64740F Planning	20
2.3.4.2 System Sizing and Costing Environment	20
2.3.4.3 An Expert System for Modeling and Analysis of Requirements and Design	21

<u>Section</u>	<u>Page</u>
2.3.5 Computer Security	21
2.3.5.1 Automated Threat Analysis Methodology	21
2.3.5.2 User Authentication	22
2.3.5.3 Secure Local Area Network (LAN)	22
LIST OF REFERENCES	23

SECTION 1

BACKGROUND

1.0 INTRODUCTION

This report summarizes the activities of Project 5720, ESD/MITRE Software Center General Support, over fiscal year 1986.

1.1 RATIONALE FOR THE SOFTWARE CENTER

The Electronic Systems Division of the Air Force Systems Command manages the acquisition and upgrade of Command, Control, Communications and Intelligence (C³I) systems. Reviews of software-intensive ESD programs frequently reveal cost and schedule overruns. Software is a significant contributor to these problems.

It is not easy to provide software for C³I systems on time and with predictable cost. C³I systems are complex, with interfaces to people, equipment, and other systems. Software supplies many of the capabilities of C³I systems, and serves as an integrator of its diverse elements. C³I requirements are difficult to define and subject to change. Software can be a means for adaptation and upgrade of a system throughout its life cycle. This means that software is on the critical path to system delivery.

The Software Center was formed to provide a focus of knowledge and resources within ESD and MITRE to support ESD programs in software acquisition and to address the problems that arise due to software in system acquisitions.

1.2 GOALS OF THE SOFTWARE CENTER

The long-term goals of the Software Center are to substantially reduce the cost and schedule risks in software acquisition for ESD systems, and to improve the responsiveness of systems to user needs by providing useful capabilities and reliable, maintainable software. To meet these goals, the Software Center must be an acknowledged leader in software acquisition.

1.3 GOALS OF PROJECT 5720 IN THE SOFTWARE CENTER

The relationship of Project 5720 to the Software Center is depicted in figure 1. The goal of Project 5720 is to help the ESD Software Design Center (XRS) to implement ESD-wide improvements in software acquisition practices and to facilitate the use of the most appropriate software engineering technology in the management and the development of software for ESD's C³ systems. Most of the staff who work on Project 5720 also spend time providing direct support to ESD programs. This facilitates the flow of information into Project 5720 on acquisition problems which recur across ESD programs and provides an outflow to programs of information on new technology and new practices.

1.4 SCOPE OF ACTIVITIES OF THE SOFTWARE CENTER

1.4.1 Direct Acquisition Support

A large portion of the Center staff has direct responsibility for software acquisition in specific ESD programs. These arrangements are usually made within MITRE between the Software Center and Project Leaders. Staff are dedicated to long-term support in software-related activities ranging from pre-RFP requirements specification through the final testing phases.

At the last count, the Software Center provided support to 43 ESD programs. These programs cover a broad range of mission areas and stages in the typical system life cycle.

1.4.2 Short-Term Support

The Software Center provides ad hoc support for program reviews and to supplement program office staff in preparing for important milestones. Software Center personnel may participate in independent review teams within MITRE or jointly with ESD. Assignments have included source selection, reviews of software aspects of RFP packages, software sizing estimates, and troubleshooting software problems during software development. At any one time, at least four people are likely to be participating in ad hoc support for reviews and still more are providing short-term support to ESD programs.

ESD/MITRE Software Center

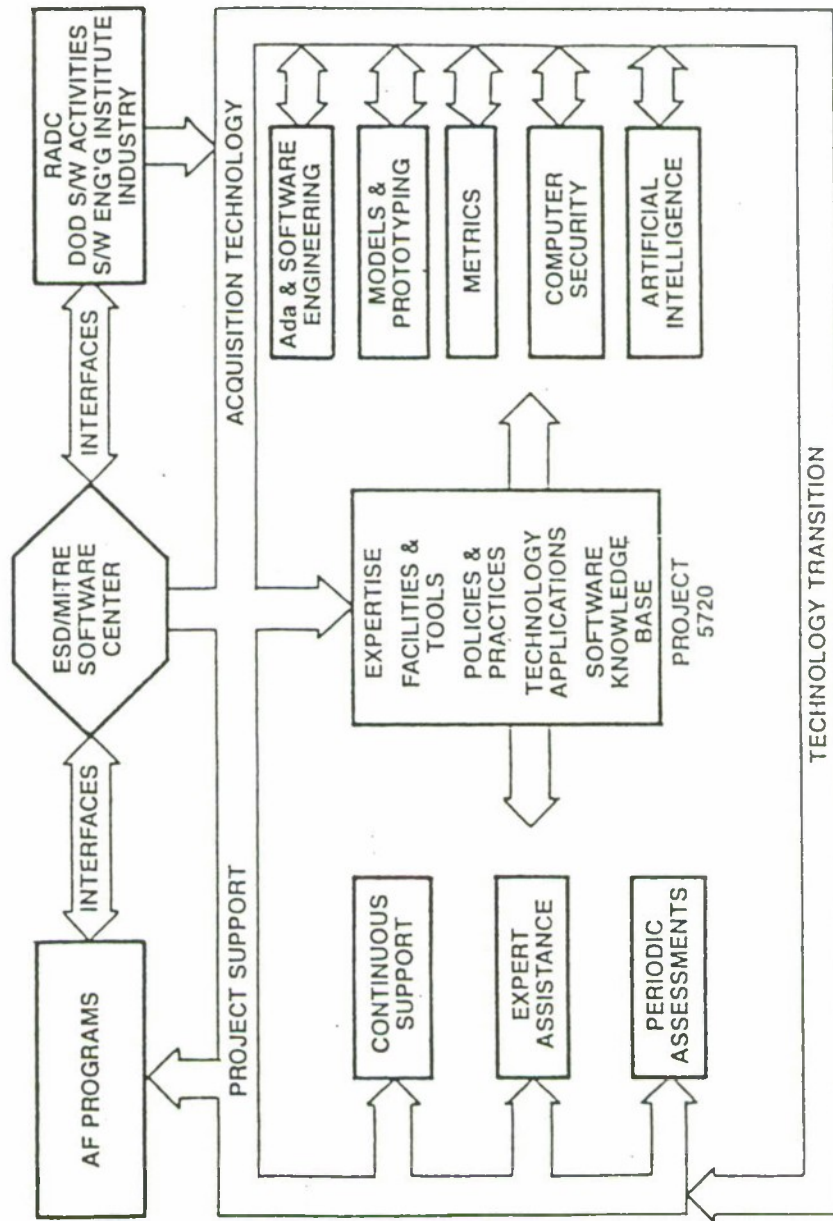


Figure 1. ESD/MITRE Software Center

1.4.3 General Acquisition Support: Project 5720

The activities on Project 5720 provide general benefits to ESD programs in all practices related to software for C³I systems. The project supports management oversight and planning for the Software Center, which numbered about 120 staff in FY86.

A role of Project 5720 is to help ESD conform to new software acquisition policy without undue risk. This requires us to develop rules of thumb for applying policies to the requirements of individual programs. Project staff also help to shape new policies by reviewing draft policy and software acquisition guidance from the DoD and Air Force, and by participating in policy-making organizations.

Project 5720 sponsors the development, standardization, and application of new acquisition procedures. It also acquires and adapts tools, and disseminates guidance that can facilitate new and improved procedures.

Project 5720 collects and analyzes lessons learned and engineering data from ESD programs in order to help plan improved software acquisition strategies, estimate software development efforts more easily, and assess the status of a software development.

Staff on Project 5720 are a skilled resource for short-term and long-term support to ESD programs. Project 5720 also provides computer facilities and tools that can be used to directly support software engineering and software acquisition management activities of programs and to demonstrate new software engineering tools and techniques.

Project 5720 staff coordinate activities with ESD management, the Software Engineering Institute, PE 64740F which is the Air Force software engineering technology application program element, RADG, and other DoD organizations. Under Project 5720, some direct support has been provided to PE 64740F, the Ada* Joint Program Office, and the DoD STARS program, which manages software engineering technology transition activities. Through these

*Ada is a registered trademark of the Department of Defense.

relationships to other organizations, Project 5720 staff maintain awareness of the state of technology and practice, and influence the direction of policy and technology to better meet the needs of ESD programs.

1.4.4 Technology Transition: Project 5720

Technology transition is the process of changing the state-of-practice to use new technology. Project 5720 performs this important function for software engineering technology. Project staff actively assess the readiness of technology for use in ESD programs and the level of risk to individual programs, find appropriate opportunities to introduce the technology at reasonable risk, and assist programs in the application of the technology. This activity often involves prototype applications of new techniques and tools in ESD programs to demonstrate technical feasibility for that program. A small portion of the effort is reserved for experimentation in preparation for new technology applications.

SECTION 2

PROJECT 5720 FY86 ACCOMPLISHMENTS

2.0 INTRODUCTION

In this section, the accomplishments of Project 5720 during FY86 are summarized. Included are activities that were initiated under Project 5720 funding and subsequently funded by specific programs, and activities for which other projects provided some of the funding. Such cost sharing with ESD programs is a part of the technology transition and acquisition support philosophy of the project.

2.1 FY86 STAFFING AND FUNDING

About 25 staff-years were spent on Project 5720 in FY86. ESD funded 20 staff-years while the remainder of the funds came from Air Force PE 64740F and the Ada Joint Program Office. These 25 staff-years represent at least twice as many individuals who spent part of their time on Project 5720 and also worked on other projects, where they supported software acquisition and performed research and experimentation. About forty percent of these were management-level people, who participated in independent reviews of programs and performed planning and quality assurance functions for the Software Center.

2.2 GENERAL ACQUISITION SUPPORT

Tasks in this area affect the practices used in software acquisition management. Their purpose is to reduce acquisition risk.

2.2.1 Policy Implementation

The objective of this set of tasks was to recommend and implement changes in software acquisition policy and practice at ESD.

In June 1985 DoD-STD-2167, Defense Software Development Standard, was approved. Its purpose was to establish a new framework that is aimed at improving the quality of delivered

software and its maintainability, and providing consistency among the Services in the procedures and the documentation for development of mission-critical software.

Under Project 5720, an ESD/MITRE team was assembled to help ESD programs tailor the new standard for use in their programs. Each eligible program's RFP package was reviewed for an appropriate choice of data requirements. An approach was used for tailoring the standard that involved classifying the software by how it was developed and delivered (e.g., commercial or new), determining appropriate Data Item Descriptions (DIDs), tailoring the DIDs, and then tailoring the activities, reviews, and products.

To acquaint Program Offices and their MITRE support with the standard, arrangements were made to present courses on 2167 at ESD and MITRE. A briefing has also been prepared to explain the main features of 2167 to Program Offices. The briefing compares 2167 to prior standards and gives an example of how it can be tailored. It will be given to ESD Program Office staff in FY87. Project 5720 staff are available to answer day-to-day questions and to review RFP packages as well.

MITRE worked with ESD in preparing an interim policy and guidance letter on implementing 2167 that gives directions for tailoring the Statement of Work (SOW), Instruction for Preparation of Proposals (IFPP), System Specification/Segment Specification (SSS), and Contract Data Requirements List (CDRL) portions of an RFP package for conformance to 2167.

MITRE has been involved in a workshop to review issues in tailoring 2167 and has helped prepare proposals for modifications to the standard or to the text that specifies it.

In preparation for its issuance, MITRE has been gathering information on DoD-STD-2168, a new software quality evaluation standard. Issues related to acquisition practices at ESD are being identified, and a briefing is planned for presentation in FY87.

2.2.2 Software Reporting Metrics

In FY85, in response to a request from the ESD commander, MITRE defined a set of Software Reporting Metrics for use during software development on ESD programs. The metrics are a few, simple quantitative items of data that can monitor trends over time in key software cost drivers and can compare actual data against plans.

They were devised to provide more widespread and more uniform visibility into the status of software developments. These metrics are intended to be warning indicators. They can tell a Program Office when to ask questions of the managers in the developer's organization in order to understand what is happening and why. The metrics were issued in FY85.

In FY86, a revision to the metrics was issued after review by ESD, MITRE, Air Force, and industry organizations [1]. During this year, the project has assisted ESD programs in collecting metrics data. A simple automated capability was assembled using a desktop computer to analyze and plot metrics data recorded in a database on a larger computer. We have begun to collect and analyze metrics data from ESD programs such as the BMEWS, MILSTAR, North Warning, OTH-B, SPADOC, and WIS programs. This will lead to improved metrics and reporting procedures.

To help introduce software management reporting, presentations on the metrics were made to staff of ESD Deputies. The metrics were tailored for programs on a case-by-case basis with the assistance of Project 5720 staff who usually met with SPO and contractor staff. In September a tally showed that while only one program is reporting all metrics, at least 15 were reporting some of the metrics and 2 were negotiating to add metrics reporting to their existing reports. Another 10 programs were scheduled to start reporting metrics when they sign contracts.

The ESD Software Reporting Metrics have become known outside ESD. AFSC has made an adaptation of these metrics which has been issued in AFSC Pamphlet 800-43, "Software Management Indicators" as a common sense approach to managing software acquisitions [2]. The metrics have been briefed at the Defense Systems Management College and conferences. Papers are scheduled for the MILCOM'86 conference and the National Joint Conference and Tutorial on Developing Quality Software, both in early October [3,4].

2.2.3 User-System Interface Design

Early in FY86, a paper was published on guidelines for graphics entry and display and incorporated into a major revision of the 1984 ESD report recommending guidelines for the design of user interface software [5]. This document completes this effort, begun several years ago under PE 64740F sponsorship. There has been a steady demand from program offices and contractors for the report.

2.2.4 Simulation, Modeling, and Prototyping

The work in this area includes many kinds of engineering activities that are used to better understand operational concepts and technical issues in ESD's systems. The results are used in defining system and software requirements, sizing the effort required to develop software, and dealing with perceived risks before the final specifications are issued. These activities provide a baseline for source selection by increasing our understanding of the key issues in designing a system, and are a means for communicating with users and developers concerning the proposed behavior of the system.

2.2.4.1 Performance Modeling

Several years ago, PE 64740F funded the development of a performance analysis tool called Automated Interactive Simulation Modeling System (AISIM). This software provides a graphic interface for creating system models in terms of the structure of a system and the resources required by system components. AISIM executes a discrete event simulation and prepares reports containing the times and resource queueing and utilization statistics based on statistical analyses of the results. Prototype use of AISIM at ESD, with MITRE assistance, has led to demonstrable benefits to ESD programs in understanding performance issues of systems in their conceptual phase as well as during planned upgrades. MITRE has helped recommend and oversee the implementation of a series of enhancements to AISIM based on our first-hand experience in its use.

In FY86, Project 5720 made AISIM available to ESD programs, provided assistance in using it, and has developed some initial models to demonstrate its utility to programs. With PE 64740F funding, MITRE has also provided system engineering and technical assistance in managing a contract for implementing the latest enhancements to the software.

There have been a number of applications of AISIM in FY86, usually funded by programs. One such application was for the proposed Survivable Communication Integration System (SCIS). Prior to source selection, a generic high-level model of the SCIS system was developed using information on the type of architecture and processors that had been seen in recent similar systems. The model was exercised with a loading similar to that in the A-level specification. Results showed processor loading and throughput time for messages, which provided insights that were a basis for discriminating among bidders' proposals during source selection.

AISIM is being used to analyze an upgrade to the MILSTAR program and also for the UHF Satellite Terminal System (USTS) in order to examine performance issues from the A-level specification.

2.2.4.2 Functional Simulation

In contrast to a performance simulation, a functional simulation models the behavior of a system or its software. Functional simulations can vary in realism depending on the purpose of the simulation and how much is known about the functional requirements.

For a number of years, Project 5720 has supported a Command and Control Concept Evaluation Capability (CONCAP), which consists of equipment, software tools, people and services to facilitate the rapid development of prototypes for portions of C³I systems. CONCAP resources have been used to initiate prototyping activities in support of specific ESD programs. If the prototyping is extensive and long-term, CONCAP provides access to facilities and services that can demonstrate the feasibility of prototyping and help to determine what are appropriate hardware and software resources for a separate prototyping facility dedicated to a particular program. In FY87, CONCAP will be merged into a MITRE-wide laboratory of prototyping and modeling facilities.

In FY86, CONCAP facilities, tools, and services were heavily used to develop a series of simulations for the Space Defense Initiative (SDI) program. Key components of the simulation use CONCAP graphics software tools. Experience with CONCAP has led to the definition and planned acquisition of more extensive facilities and tools specifically for SDI. That same experience, and some of the software from the SDI simulation, were used to generate an initial Air Defense Initiative (ADI) Simulation within a month.

With CONCAP tools, a prototype system that facilitates the handling of data calls for program funding information was completed for ESD/XR. CONCAP was used for the Sentinel Bright project to implement representative display software in order to derive size estimates. For the MILSTAR program, a terminal prototype is being developed to examine user interface issues. The prototype has been demonstrated with various scenarios to the contractor as well.

Under Project 5720, functional simulations of software designs were also developed this year. From the A-level specification and the initial software design, a model of the interactions of the Computer Program Components (CPCs) in the software architecture of the Joint STARS system was created. Its purpose was to better understand the nature of the interfaces, the data and control flows

of significance, and the response of the system to various external events. Useful information was derived concerning the software architecture from the modeling effort, which was programmed in Ada.

2.2.4.3 Simulation and Modeling Day

To encourage the use of simulation and modeling and to facilitate technical interchanges, Project 5720 arranged a Simulation and Modeling Day. A series of MITRE speakers presented their approaches to using prototyping and simulation and their impact on the ESD programs. The conclusions of the meeting were that we are using modeling and simulation techniques and important decisions are based on the results. We tend to select tools that are readily available, rather than finding the optimum tool. We are also making progress in applying knowledge-based tools to simulation, modeling, and prototyping.

2.2.4.4 Display Rapid Prototyping System

PE 64740F has identified a requirement for a Display Rapid Prototyping System (DRPS) that can support definition of user requirements for C³ Systems. DRPS will permit the rapid development of simulations of the operation of a system, its timing, and designs for the user-system interface. Two contractors have been chosen to compete in a study leading to specifications for a new tool. MITRE will provide systems engineering and assistance to ESD in contract management.

2.2.5 Information Collection and Dissemination

Project 5720 is responsible for collecting information relevant to software acquisition and for providing that information to those at ESD who can use it. This service takes several forms.

2.2.5.1 Helpline

The project maintains a Helpline, a single telephone number for receiving answers to software acquisition questions. The Helpline is backed up by a database of contacts for specific subjects and an indexed log of prior questions.

2.2.5.2 Newsletter

Project 5720 publishes an internal quarterly newsletter with short summaries of software acquisition activities and accomplishments that might be useful to the ESD/MITRE community.

Each article gives a point of contact. Our experience has shown that many of the articles lead to inquiries and further exchanges of information.

2.2.5.3 Software Acquisition Library

In FY86, we initiated a collection of software acquisition documents from the private holdings of MITRE staff. These documents can provide valuable guidance but have been difficult to access. They include examples of good products from prior software acquisitions, or guidance produced within a project or in some other organization. The collection has been catalogued and filed. A computer allows browsing through the index. In the next fiscal year, it will be more closely integrated with other online library services.

2.2.5.4 Courses, Seminars, and Symposia

In conjunction with ESD and with the MITRE Institute, courses related to software acquisition have been offered locally in FY86. Project 5720 staff have helped to plan the contents of the courses, to evaluate potential speakers, and to teach the courses in some cases. Over 160 students attended courses on DoD-STD-2167. At least another 100 students attended other courses related to software acquisition.

At the start of FY86, two courses organized and taught by Project 5720 were completed. One was "Software Acquisition: Policy, Terminology, and Standards." The other was "Introduction to Ada and Software Engineering." A course entitled "Software Engineering: Programming Support Environments," was offered at the MITRE Institute in March.

Ada was the subject of several courses. About 35 people attended an "Introduction to Ada" programming course in June, taught by Professor R. Vidale of Boston University. A one-week intensive course, "Design for Ada Software," by Mr. Ed Berard was arranged with the MITRE Institute at the request of MITRE people for August because the earlier course had been oversubscribed.

An advanced workshop/seminar on Ada issues was conducted by Professor Vidale and MITRE personnel. The course dealt with design methodologies, run-time performance issues, Ada and DOD-STD-2167, Ada issues in security, and Ada as a PDL. The materials prepared for this seminar will be used as a basis for the development and dissemination of a set of recommended practices for Ada software acquisition.

In FY87, courses are planned in Software Acquisition: Policy, Terminology, and Standards; and Programming in Ada.

2.2.5.5 Technical Interchange Meetings

Technical interchange meetings have been arranged within MITRE on particular subjects. In FY86, these have included Simulation and Modeling, Ada, and Artificial Intelligence Applications. The AI Applications meetings have been scheduled on a monthly basis. These meetings allow us to share experiences in applying expert systems on programs throughout ESD and at MITRE's Washington operations, and to establish connections for further exchange of information.

Other technical interchanges have been arranged with industry organizations to learn about their software engineering research activities and to review recent products. These meetings are coordinated with ESD, and Air Force representatives attend.

2.2.5.6 ESD/MITRE Software Acquisition Symposium

Successful acquisition of software in ESD systems must be a joint effort of the end user organization, the Program Office, and the contractors who develop the software. In order to involve industry in proposing and implementing improvements in software acquisition practices at ESD, a Software Acquisition Symposium was organized under Project 5720 in May 1986. Key leaders from ESD software contractor organizations and ESD managers met to discuss recent experiences in software acquisition, to examine major causes of difficulties, and to suggest improvements in Government and industry policies and practices for software acquisition at ESD. A compendium of the visual presentations was issued to attendees [6]. For the ESD/MITRE community, videotapes of the sessions are available. Proceedings have been published since the end of the FY86 [7].

Among the recommendations of the Symposium were the following:

- Modify the acquisition strategy for C³ systems.

The focus was on more prototyping and engineering studies prior to initial system design. Both the user and developers should participate in this activity. This would result in a better understanding by all parties of the requirements of the system and the software, and would provide a better basis for sizing and costing the software. We need to allow adequate time prior to commitment to full scale development for these activities.

Because of the changing nature of C³ system requirements, most developers endorsed an evolutionary or incremental acquisition with early delivery of well-established capabilities and user feedback alternating with definition and delivery of new or changed capabilities. Everyone agreed on the importance of firm requirements and design at the time of Preliminary Design Review for each system increment.

A successful acquisition strategy must also consider business practices such as contracting. Industry leaders pointed out the difficulty of bidding on a fixed-price contract for Full Scale Engineering Development when little is known about the software requirements. A multi-phase effort could allow sufficient analysis to be performed to increase the certainty in the cost estimate prior to awarding a fixed-price contract. Contractors also cautioned that any incremental or multi-phase contracting approach can be damaged if there are gaps in funding that prohibit the contractor from keeping the software team together. A method of bridging the funding gaps is needed.

- Stronger management oversight and more disciplined procedures should be used.

There was a general endorsement by industry of the ESD Software Reporting Metrics and of both internal contractor and government audits of software status. Some speakers felt that DoD-STD-2167 would provide a more disciplined approach to software development and greater visibility to managers of the status and quality of the effort. Many contractors are developing internal standards that are compatible with 2167. The cautionary note on DoD-STD-2167 was to change the strategy, as described above, to include more prototyping and risk management.

- For large productivity and quality improvements in software engineering, integrated programming support environments should be used.

Several speakers acknowledged a shortage of software engineers to develop large, complex C³ systems. Suggested remedies included development of programming support environments with workstations and tools to support software development activities and project management. These environments would serve to enforce standard software development procedures and hopefully would improve productivity. A number of contractors described internal efforts to provide environments. In the near term, they automate more routine functions such as documentation generation and configuration management. Over the longer term, larger gains in productivity might be achieved by increased reuse of software and by expert

systems and knowledge bases to support the process of software development and maintenance.

A practical issue in the use of programming support environments is DOD policy on data rights: who owns software used to develop DOD systems. The results of a Software Engineering Institute study on DOD data rights policy were presented. It was noted that the current laws concerning software rights are confusing at best. Some revisions may be needed to provide economic incentives for industry to develop programming support environments and use them on DOD programs, and for industry to reuse application software as well.

- The Ada language and programming support environments are beneficial to C³ systems in the long run and should be used now.

Speakers indicated that programs that are being developed now for long-term operation must use Ada, since other current languages will be increasingly less effective in meeting the demanding requirements of these systems over the next 20 years.

Ada must be introduced in measured steps, which control risk and allow vendors to increase the capabilities of compilers and other tools. Speakers recommended the following: Ada as a Program Design Language now; testing of available Ada tools and environments for specific applications; training for both developers and managers (in industry and in government); prototype applications of Ada; and more focus on real-time applications, distributed systems, and fault-tolerant features in new Ada compilers.

A final recommendation was made that we look more closely at the effect of Ada on software maintenance before we begin to field Ada software.

2.3 TECHNOLOGY TRANSITION

Recent studies have shown that the transition of software technology from an experimental state to common practice takes as long as 17 years. Project 5720 has a strong responsibility to accelerate the technology transition process for software engineering without causing undue risk to ESD programs.

Technology transition requires knowledge of the readiness of technology for use and opportunities to apply it. The best vehicle we have found for accomplishing that transition is people. Therefore, Project 5720 provides the knowledge of technology and

encourages people to move from the project to acquisition programs with that knowledge. In addition, Project 5720 broadcasts information to the ESD/MITRE community through briefings, seminars, and publications. Where deficiencies are found in the direction of current technology for ESD requirements, Project 5720 staff take steps to influence efforts of other organizations, and to look for solutions themselves.

The technology transition efforts in Ada, Artificial Intelligence applications, and Computer Security for FY86 are described below. The latter two areas of technology transition were supported by AF PE 64740F, Computer Resource Management Technology.

2.3.1 Introduction of Ada at ESD

The goal of the Ada introduction task is to facilitate the successful introduction of Ada into ESD programs through acquisition support, technology application, training, and participation in the government and industry Ada community.

2.3.1.1 Acquisition Support

Project 5720 staff have provided consultation and short-term support to over 10 ESD programs in dealing with Ada-related issues such as RFP preparation, source selection, and contractor product review. Staff have also participated in ESD and MITRE review teams, and have worked with contractors to help solve problems with Ada performance during acquisition.

The Software Center and Project 5720 have provided assistance to an ESD program in developing an innovative technique for evaluating bidders' software development methodology and use of an Ada Design Language. During the Full Scale Development source selection, each bidder will be given a software engineering exercise in which he applies his software development methodology on a sample problem. The objective is to illustrate the bidders' design approach and interim products that use Ada for design. Project 5720 staff are working jointly with the Program Office staff to do a practice application of the exercise in order to refine it, to anticipate issues that may arise during bidders' use of it, and to produce objective source selection criteria to be used in evaluating the bidders' performance.

While the programs usually bear much of the cost of such activities, Project 5720 assures that people with the necessary skills and knowledge are available and verifies the feasibility of such recommendations if necessary.

2.3.1.2 SAC Ada Development and Maintenance Study

Project 5720 funded a study to help develop an approach to Ada software development and maintenance at SAC. The study surveyed selected SAC systems to identify candidates for an Ada transition study. After surveying relevant software technologies, the components of a software development and maintenance environment were recommended to meet the needs of SAC directorates. In the final phase, completed in mid-FY86, a transition plan was proposed for a specific set of SAC systems to adopt an Ada environment and to train for its use. The study advocates use of a standardized Ada software development and maintenance environment.

2.3.1.3 Technology Application

Firsthand application of Ada technology in the context of ESD system requirements and ESD policies and practices allows MITRE to experience the strengths of Ada and to devise solutions to problems which may arise in the use of Ada at ESD.

2.3.1.3.1 An Application of Ada Design Methods

In FY85, an investigation was begun into how Ada could be used as a Program Design Language (PDL) along with formal software development methods. The investigation took the form of a model design exercise called MIMSY. A top-level design was developed and documented in accordance with procedures and documentation specified in DoD-STD-2167. Two versions of the Software Top-Level Design Document were produced. Each was about 40 pages long, with 85% of each being Ada PDL.

To enhance the realism of the design exercise, personnel were assigned roles corresponding to those of the typical organizations involved in software acquisition, and formal reviews were conducted through a second Preliminary Design Review.

A combination of existing design methods, formal design languages and design notations were selected from current technology. The results are documented in an ESD Technical Report [8]. The results were also presented at a recent SIGAda conference. The investigation confirmed the usefulness of formal design methods and notations with Ada, provided developers and reviewers are familiar with the techniques. A tasking model of system behavior was also recommended.

2.3.1.3.2 ESD Acquisition Support Environment (EASE)

In preparing for the use of Ada in ESD programs, we realize the need for tools that will more effectively support the systems engineer's role of analyzing, evaluating, and managing Ada products of software developers. Under Project 5720, we have begun to provide an open, extensible architecture for integrating independently developed tools with capabilities for analyzing Ada software. This environment is called EASE.

In FY86, the initial framework was designed and is being developed for rapidly integrating existing Ada-based tools. Many tools that run under Unix* including editors, testing tools, and formatters can be incorporated now. Building on existing capabilities in a Sun** workstation, we have added a set of process control primitives to make it easier to integrate tools. In FY87, specification and implementation of a common data representation will be initiated to integrate data flow for all EASE tools.

Because of the similarities between programming support environments and EASE, this effort provides us with insights into the status of environments for developing Ada software and will result in useful tools for analyzing Ada products in software acquisitions.

2.3.1.3.3 Ada Functional Simulation

In Section 2.2.4.1, the use of functional simulations to analyze software designs was described. Three such models were developed in Ada for ESD programs. The model developments had a dual purpose: to provide analyses of designs, and to learn how Ada can be used for high-level simulations. The conclusions concerning Ada were that some difficulties existed in using a strongly-typed language to represent abstract, high-level designs, and some problems with representing timing. The tasking model of the Ada language was suited for behavioral models.

* Unix is a registered trademark of AT&T.

** Sun is a registered trademark of Sun Microsystems.

2.3.2 Ada Joint Program Office Support

A small amount of support has been given to the Ada Joint Program Office (AJPO) in specification of the Common Ada Programming Support Environment (APSE) Interface Set (CAIS). The CAIS is a standard operating system interface. Its purpose is to allow the interchange of Ada programming tools and project data among environments on different computers and under different operating systems.

2.3.2.1 Prototype CAIS

The objective of this task is to build a prototype CAIS by implementing a full operating system in Ada for the Intel 80386 microprocessor. This prototype will provide important feedback about the implementability and performance characteristics of the CAIS to its developers before standardization. In FY86, parts of the design were completed, including the lowest levels closest to the hardware, a virtual memory mechanism and part of the task scheduler.

2.3.2.2 CAIS Consultation

In the past two years with the sponsorship of other projects, MITRE has implemented the CAIS under several operating systems and has extended its design to support distributed processing over local area networks. A small task under Project 5720 this year has provided the Ada Joint Program Office and other organizations with the expertise gained while MITRE performed this research. Specifically, MITRE has provided answers to technical questions and provided advice to the Kernel Ada Programming Support Environment (KAPSE) Interface Team (KIT), the KAPSE Interface Team from Industry and Academia (KITIA), the CAIS Working Group (CAISWG), and the AJPO. MITRE has also provided written comments on specific technical issues and reviews of the proposed Military Standard CAIS specification.

2.3.3 Ada Community Participation

Under Project 5720, MITRE has actively participated in organizations that develop and influence Ada technology and policy. This has allowed us to maintain current information about technology, policy, and experience, and to communicate the experiences and concerns of ESD to those organizations.

MITRE staff are permanent members of the KIT/KITIA and the APSE Evaluation and Validation Teams. We have also participated in other

workshops and professional group meetings. A talk was delivered at a recent SIGAda meeting on the our Ada work.

2.3.4 Artificial Intelligence Applications

The purpose of these tasks to to help ESD programs to understand and use AI technology. The approach has been to obtain and use representative state-of-the-art hardware and software for applications in which the users are an ESD Program Office and a MITRE systems engineer. These prototypes show how well the technology can be used, the effort and skills required for its use, and the process to acquire expert systems. All of this information is needed to advise ESD programs on the application of expert systems, and may result in tools that improve system and software acquisition at ESD.

The work in AI applications was partly supported by PE 64740F, and influenced by other AI research and experimentation at MITRE, under Air Force and NASA sponsorship.

2.3.4.1 PE 64740F Planning

PE 64740F has responsibility for transitioning technology for the management of software acquisitions. MITRE is providing the program with a survey of the status of AI research and development work that might be applied to projects within this program element. A number of specific tasks have been identified for the program to sponsor.

2.3.4.2 System Sizing and Costing Environment

The objective of this task is to develop a knowledge base and automated aids capable of helping an analyst to relate the functional requirements of a C³I system to the level of effort required to build the system. This is a technology prototype which uses expert system technology to aid in software project management. For most software cost models, the accuracy of the estimate depends on how well the analyst can estimate the level of effort required to develop software, which in turn depends on estimates of its size and complexity. It is difficult to make such estimates from the functional requirements alone. This capability will provide models of typical C³ systems to be used in cost estimation from specifications before designs exist. Sizing information related to functional requirements will also be included in the knowledge base.

In FY86, a demonstration has been prepared to illustrate types of capabilities that might be provided and to AI techniques for achieving them. During the latter half of FY86, this work was funded by PE 64740F and will continue into FY87.

2.3.4.3 An Expert System for Modeling and Analysis of Requirements and Design

As part of the AI Applications technology transition activities, another early prototype has been developed that uses an expert system building tool (Intellicorp's Knowledge Engineering Environment (KEE)) for its implementation. This enables MITRE to demonstrate and assess the impact of such tools on the acquisition process for expert systems.

The prototype will support the generation of requirements specifications and their representation as text, graphic schematics, and models that can be analyzed. It will contain a knowledge base of typical C³ system requirements and system designs so a user can build a specification from generic examples of similar systems. Representations will be available for expressing functions and their relationships, interfaces, and expected behavior. Requirements and designs will be analyzed for completeness and consistency, individually and between them. Dynamic analyses would allow the system behavior to be observed in response to simulated inputs, and performance information to be collected.

This year, an initial prototype has been demonstrated to illustrate capabilities that seem useful and feasible. A framework has been designed for implementing capabilities. The results have been described for several technical workshops.

2.3.5 Computer Security

MITRE has performed a number of tasks in Project 5720 for the Computer Security program of PE 64740F. The objective of the Computer Security Applications task is to help ESD and the Air Force Computer Security Program Office (AFCSPO) to transition computer security technology into the Air Force. There were two efforts under the project: risk analysis technology support and expert systems for authentication.

2.3.5.1 Automated Threat Analysis Methodology

Air Force regulations mandate periodic risk analysis of ADP systems, facilities, and installations, as part of an overall security program. MITRE provided both a conceptual framework for

risk analysis of an ADP facility and specific guidelines for risk analysis tasks based on facility size, complexity, and data sensitivity. It included forms for gathering information and examples of threats and countermeasures to aid the risk analyst.

MITRE has given systems engineering support to ESD for monitoring a contract to develop a production-quality automated risk analysis tool based on the prototype Automated Threat Assessment Methodology (ATAM) developed at MITRE in FY84 - FY85. During FY86, the prototype was demonstrated at SAC.

2.3.5.2 User Authentication

The objective of this task is to apply current artificial intelligence technology to the problems of authenticating a user of a computer system. During FY86, a literature search was conducted and a model proposed which involved asking the user questions from his/her own experience. During a registration phase, a valid user enters a set of questions and acceptable answers. These questions are then selected for use at logon to authenticate the user. After experimentation, a prototype was developed. Other techniques are being explored in addition to this solution.

2.3.5.3 Secure Local Area Network (LAN)

ESD has a contract with Verdix Corporation under the Small Business Innovative Research program which has resulted in the design and development of a prototype of the Verdix Secure Local Area Network, which provides multilevel secure datagram-level service to LAN nodes. In the next phase, Verdix will install the prototype and evaluate it in a specific Air Force application. MITRE is contract monitor and will assist in selection of the user site, and reviewing contractor progress. This work began late in the fiscal year with a review of the Statement of Work for the next phase of the contract.

REFERENCES

- [1] Coles, R.J. et al, "Software Reporting Metrics," ESD-TR-85-145, AD A163 756, Electronic Systems Division, Hanscom AFB, MA, November 1985.
- [2] Department of the Air Force, Headquarters Air Force Systems Command, AFSC Pamphlet 800-43, Software Management Indicators, 31 January 1986.
- [3] Schultz, H.P., "Software Reporting Metrics," MILCOM '86, 1986 IEEE Military Communications Conference, Paper Number: 86CH2323-4/86/0000-0085, Monterey, CA, October 1986.
- [4] Schultz, H.P., and Owens, M.F., "Software Reporting Metrics," NSIA National Joint Conference and Tutorial on Developing Quality Software, San Diego, CA, October 1986.
- [5] Smith, S.L. and Mosier, J.N., "Guidelines for Designing User Interface Software," ESD-TR-86-278, AD A177 198, Electronic Systems Division, Hanscom AFB, MA, August 1986.
- [6] ----, ESD/MITRE Software Acquisition Symposium, "Speakers' Visual Presentations," The MITRE Corporation, Bedford, MA, May 6-7, 1986.
- [7] ----, ESD/MITRE Software Acquisition Symposium Proceedings, ESD-TR-87-177, Electronic Systems Division, Hanscom AFB, May 1986.
- [8] Byrnes, C.M., "The Application of ANNA and Formal Methods as an Ada Program Design Language," ESD-TR-86-276, AD A175 120, Electronic Systems Division, Hanscom AFB, MA, October 1986.