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Carnegie Mellon University
Software Engineering Institute

Quarterly Update

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Carnegie Mellon University
Software Engineering Institute

Quarterly Update

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April-June 1989

Director's Overview

The second quarter of 1989 was an eventful one for the SEI. We held our annual SEI Affiliates Symposium on May 2-4, 1989, in Pittsburgh. This year's symposium included one day of tutorials and workshops followed by two days of briefings and conference sessions. I was pleased that 358 people from affiliate organizations attended and that many participants offered valuable feedback on SEI work. The 1990 SEI Affiliates Symposium is scheduled for September 11-13, 1990, in Pittsburgh. We look forward to hearing from affiliates then and throughout the year.

The SEI played a large role in organizing the 11th International Conference on Software Engineering (ICSE), which was held in Pittsburgh on May 16-18, 1989. This conference was jointly sponsored by the IEEE Computer Society Technical Committee on Software and the ACM Special Interest Group on Software Engineering. ICSE was attended by more than 1100 people from 20 countries. I served as the general chair, Norm Gibbs was the tutorials chair, and Nancy Belz was the local arrangements chair. Other members of the SEI participated as presenters, panelists, program committee members, tool presenters, exhibitors, and session chairs.

Several other significant events were held during this quarter, including the Software Engineering Process Group Workshop (p. 5), the Measurement Steering Committee Meeting (p. 5), the Sixth IEEE Workshop on Real-Time Operating Systems and Software (p. 13), and the Third International Workshop on Real-Time Ada Issues (p. 21).

The SEI provided a variety of training and educational opportunities during this past quarter. We conducted self-assessment training for 40 participants (pp. 4, 23), and completed Software Verification and Validation (p. 18), an Academic Series course, and Software Project Management (p. 18), the first Continuing Education Series course. In addition, the first Technology Series videotape, *Software and Some Lessons Learned from Engineering* (p. 18), was released this quarter.

Several of the SEI projects that involve the development of prototype systems have useful products available to interested organizations. This quarter, the Distributed Ada Real-Time Kernel (DARK) was distributed to nine new acceptor sites (p. 14) and three additional companies signed on as acceptor sites for the Serpent user interface management system (p. 14). Furthermore, the SEI began distributing the source code for the SQL Ada Module Extensions standard packages, which enable the binding of Ada and SQL (p. 21).

Between April and June 1989, the SEI signed on two new academic affiliates (p. 16) and nine new industry affiliates (p. 23). In addition, three new resident affiliates joined the SEI (p. 23). I encourage more organizations to consider sending resident affiliates to the SEI. Resident affiliates mutually benefit the SEI and their home organizations by applying their expertise toward working with us on significant issues that affect the whole software engineering community.

Larry Druffel, Director

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Software Engineering Process

The Software Engineering Process Program focuses on improving the process of software development. Projects within the program are assessing the actual practice of software engineering in the defense community, training organizations to gain management control over their software development processes, and establishing a network of process groups to improve their software capability.

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**Software Process
Assessment**

The Software Process Assessment Project assists software organizations in launching effective process improvement programs, characterizes and reports on the software engineering capabilities of defense contractors, and defines priority needs for software process improvement in the defense community.

Project members completed their review of the Westinghouse Electronic Systems Group (WESG) action plan to make process improvements, and SEI and WESG professionals held a meeting to discuss the SEI's response.

SEI-assisted assessments were completed for Ford Aerospace and McDonnell Douglas during this quarter.

In conjunction with staff from the SEI Transition Training group, project members conducted self-assessment training for 40 participants from several SEI affiliate organizations. The training prepares affiliates to assess software development processes within their organizations.

In May 1989, the project conducted a process assessment of an SEI project. This internal assessment provided insight into software development within the SEI and allowed Process staff to gauge how the assessment tool scales down to a smaller organization.

At the 11th International Conference on Software Engineering, the project leader gave a presentation describing the project's state-of-the-practice reporting effort.

The project leader presented the keynote speech at the first annual Naval Ocean Systems Center (NOSC) Software Engineering Symposium in San Diego. The symposium was sponsored by NOSC's new software engineering process organization, which was created as a direct result of the SEI-assisted assessment conducted at NOSC in January 1988.

The Software Process Development Project supports improvement in the software engineering process through software engineering process groups (SEPGs), guides, workshops, working groups, and training courses. Using data gathered from the Software Process Assessment and Software Capability Evaluation Projects, this project identifies priority needs for process improvement, selects methods and practices to meet these needs, and works with organizations to improve their methods and practices.

The second annual SEPG Workshop was held June 21-22, 1989, at the SEI. Forty-five invited participants from industry and government organizations met to discuss their experiences in establishing and sustaining process improvement within their organizations. Individuals attending the workshop are currently participating in an ongoing process group in their organization. Presentations were made on total quality management, metrics, and human resources issues that relate to the process maturity framework. This workshop was used to foster dialogue among peers from different organizations and to collect ideas for future support that the project will provide to process groups.

The project, in collaboration with staff from the SEI Technology Transition Program, completed a draft version of the *Software Engineering Process Group Guide* in June 1989, and distributed it for external review at the SEPG Workshop. This report provides guidance on establishing and operating an SEPG and will serve as the basis of a future SEI publication.

The first meeting of the Measurement Steering Committee was held in April 1989 at the SEI. This meeting launched a national initiative that the SEI is leading to bring software process metrics into more general use. The use of metrics will provide a more explicit and formal basis for evaluating and improving the software development process. The meeting was attended by approximately 20 authorities on measurement, drawn from industry, government, and academia.

The Measurement Steering Committee established two measurement working groups: one for metrics definition and one for metrics acquisition. The first group will define a basic set of measurements. The second will define the requirements to obtain the metrics and will account for different viewpoints and usage in practice, validation, verification, precision, and accuracy. The first meeting of the measurement working groups was held at the SEI on June 20, 1989. Approximately 50 people attended. The project will continue to support the measurement initiative by facilitating the meetings of the steering committee and the working groups.

The fifth pilot session of the software inspections course was taught to General Dynamics in Fort Worth, Texas. This course, developed in collaboration with the SEI Transition Training group, teaches a method for effectively conducting peer technical reviews of software products, including specification, design, test plans, test results, and code. It instructs practitioners in cost-effective methods for detecting and removing defects early in the software life cycle.

The project initiated a program management effort to help government program offices understand and use process principles when acquiring software and monitoring software contracts. The project has direct support funding from two Electronic Systems Division programs: Cobra Dane and Mission Planning System; and two Communications and Electronics Command (CECOM) programs: Operational Tactical Army Data Systems (OPTADS) and Forward Army Air Defense Command and Control (FAADC2). The purpose of the program management effort is to help government acquisition organizations to be better customers. Working with government program managers provides the SEI with an opportunity to increase the application of software capability evaluation and provides incentive to contractors to continually improve their process maturity.

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**Software Capability
Evaluation**

The Software Capability Evaluation Project helps DoD acquisition organizations to evaluate the software capability of contractors to perform competently on DoD contracts. The project is improving and transitioning an evaluation method for use in software-intensive acquisitions.

Project members updated their plan for revising the questionnaire used to help identify the maturity of an organization's software capability. This revision incorporates suggestions from industry for an extensive public review and a revision control system. The project expects to complete Version 1 of the software capability questionnaire in the summer of 1990.

Project members made presentations to CECOM program engineering offices and collected feedback on the project's evaluation method. The project is supporting CECOM, which is using capability evaluations in its acquisition activities.

Project members also trained representatives from seven logistic centers in the Air Force Logistics Command to use the capability evaluation method. The method was applied in June 1989 on the command's source selection for a major F-111 upgrade.

In June 1989, project members made presentations to the Aircraft Weapons and Systems Integration Department at the Naval Weapons Center (NWC), and arranged to train two evaluation teams from NWC in July 1989.

The project leader met with representatives of the Air Force Systems Command (AFSC) and the Air Force Aeronautic Systems Division (ASD), who are producing a regulation describing the use of pre-award surveys in source selection. The project's evaluation method will be included in the regulation.

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**Process Program
Reports**

CASE Planning and the Software Process
(CMU/SEI-89-TR-26)

April-June 1989

For information on how to order reports, see page 28.

Software Engineering Methods

The primary objective of the Methods Program is to improve the practice of software engineering by improving individual and team productivity through the identification and transition to practice of emerging software technology. Promoting the appropriate use of this technology supports the SEI effort to transform software development from an ad-hoc, labor-intensive activity to a technology-supported engineering discipline.

..... Software Development Environments

A continuation of the Evaluation of Environments Project, this project is investigating emerging environment technology and its transition to practice. Specifically, the project is studying the problem of tool configuration management and is tracking the state of environment architectures, with a focus, in particular, on configuration management functionality.

To address problems concerning the assembly, integration, and evolution of third-party tools in environments, the project is developing a prototype tool that supports the configuration management of tools in a distributed workstation environment. This quarter, project members completed the first stage of analyzing the requirements for the data modeling aspect of this prototype, and performed an analysis of tool parameterization techniques.

Focusing on advances in configuration management, project members are examining several commercial environments for their support in managing software evolution. The underlying configuration management models are being analyzed and compared, and newly introduced configuration management concepts are being determined. The results of this work are being communicated to cooperating government agencies, through reports and presentations.

A chapter describing the state of the practice of software development environments was reviewed and submitted for publication to the American Institute of Aeronautics and Astronautics (AIAA) as part of an AIAA Progress Series Book on Aerospace Software Engineering.

Also this quarter, project members gave an invited talk at the USENIX Software Management Workshop, participated and presented at the Services Backplane Forum under the auspices of the National Institute for Standards and Technology (NIST), and attended a program committee meeting for the Second International Workshop on Software Configuration Management.

This project is examining the use of traditional and formal methodologies in the specification of embedded applications.

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**Specification and
Design Methods
and Tools**

This quarter, the project specified a problem using four methodologies (Ward/Mellor, Hatley/Pirbhai, Harel, and Extended Systems Modeling Language), and is evaluating these specifications against a set of previously established evaluation criteria. Developers of the methodologies are also reviewing the specifications. To investigate the experience of others in using these methodologies, project members visited six companies that produce commercial or military software (Hewlett-Packard, Motorola, MITRE, Ford Aerospace, Kaiser Electronics, and Smith Industries). The knowledge and experience gained from this effort will be reported to the software community to help developers select appropriate methodologies for designing embedded applications.

Also developed this quarter was a taxonomy of characteristics for formal methods that are applicable to specification of concurrent systems. Project members visited developers and users of some popular concurrent and sequential formal methods to discover the extent of their usage, the state of tool development, and the advances being considered. Project members also discussed the taxonomy and were advised on changes and extensions to it.

To develop a fundamental understanding of structures for the software architecture level of design, this project is describing basic design elements used in the description, analysis, and development of software systems.

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**Software Architecture
Design Principles**

The project is preparing a report describing the results of a survey of several software system architectures. The immediate beneficiaries of these results will be research and development groups working on architectures in specific application domains.

The project leader gave a seminar on software architectures at the University of Maryland. She also made a presentation at the Fifth International Workshop on Software Specification and Design, an invited workshop held after the 11th International Conference on Software Engineering (ICSE).

The project leader, with research staff from the Robotics Institute at Carnegie Mellon, began a collaborative study on the content knowledge a software engineer should have and how that knowledge should be communicated.

A videotaped lecture by the project leader on the history of engineering is available through the SEI Education Program, and a short (20-minute) version is being used in conjunction with an SEI continuing education course. (See page 18 for more details.) The project leader gave a seminar on the subject at Queens University. She also made a presentation at ICSE on the past 20 years of software engineering; the related paper appears in the conference proceedings and in *Annals of History of Computing*.

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**Software Process
Modeling**

The Software Process Modeling Project is investigating techniques for modeling the software development and maintenance process.

In April 1989, a walk-through with the Pacific Missile Test Center was held to verify the project's model of the F-14 software maintenance process. Work began on refining the model according to the results of this walk-through, and project members are preparing to add simulation to the model.

Project members discussed the technical approach, progress, and long-term direction of the F-16 modeling effort with representatives from the Air Logistics Center at Ogden Air Force Base.

At the 11th International Conference on Software Engineering (ICSE) in May 1989, project staff presented a paper on entity process models and participated in a panel discussion on modeling the software process.

A position paper, "Software Maintenance: A Fresh Perspective," and a panel summary report, "Non-Traditional Perspectives on Software Maintenance," were completed for publication in the *Proceedings of the 1989 Conference on Software Maintenance*, scheduled for October 1989.

Software Systems

The goal of the Systems Program is to improve the development of real-time distributed systems by integrating software engineering with systems engineering and reducing the risk of new technology.

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**Real-Time Embedded
Systems Testbed**

The Real-Time Embedded Systems Testbed (REST) Project is collecting, classifying, generating, and disseminating information about software development for real-time embedded systems.

The project began experimenting with the Inertial Navigation System (INS), an Ada artifact developed by the project. The initial experiment, started in June, is to perform a schedulability analysis of the INS. As part of this experiment, a schedulability model of the INS will be generated. A second experiment, which is being prepared, is to perform a detailed comparative analysis of two implementation paradigms (the Task Dispatcher and Delay-Until models) that can be used to implement periodic Ada tasks. Other experiments are planned.

Project members continued developing and experimenting with Hartstone, a benchmark series directed specifically at real-time embedded computer systems. Project members developed several prototype versions of Hartstone benchmarks, and are reconciling the various versions. Versions were sent to five compiler vendors and five applications developers for review and feedback. One vendor discovered that the benchmark is a good stress test of its Ada runtime system; the benchmark has uncovered a significant bug in the runtime system. A formal release (Version 1.0) of the initial Hartstone test series is being prepared.

The Real-Time Computing Network (RTCN) was installed and is undergoing initial testing. The RTCN, a fiber-optic network that IBM supplied to the SEI, provides the testbed with a distributed target system for experimentation and analysis.

The project is providing support to the Naval Surface Warfare Center (NSWC) on the Shipboard Gridlock System with Auto-Correlation (SGS/AC) program. The project is developing performance benchmarks to assess the performance of the Ada version of SGS/AC and is evaluating design methodologies associated with polled and interrupt driven systems. The task includes an assessment of procedures that allow quantitative comparison of alternative designs. Work is expected to be completed later in 1989.

A preliminary evaluation of the DDC-I Ada cross-compiler for the Intel 80386 processor was undertaken for the F-16 VHSIC Core Avionics Processor (VCAP) Project. The SEI was contracted by Hill Air Force Base in Ogden, Utah, to help with this project. The REST project effort involved compiling VCAP software under the DDC-I compiler so that the generated code could be analyzed by the VCAP contractor, General Dynamics in Fort Worth, Texas.

The Real-Time Scheduling in Ada Project is demonstrating how to design and implement real-time systems using analytic scheduling algorithms.

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**Real-Time Scheduling
in Ada**

A plan outlining experiments for evaluating the performance of the project's runtime implementation was completed, and experimentation began. Project members will conduct performance tests of various implementations of the scheduling algorithms for the VADS/Unix runtime system. These tests will provide empirical results that will be used to evaluate the scheduling theory. Moreover, the results will be used in the avionics case study.

The implementation of the avionics case study is complete. A draft report describing the avionics case is being prepared by IBM and will be reviewed in the next quarter. The test case was developed in association with the Naval Weapons Center at China Lake, California, and IBM in Owego, New York. This test case will be used to demonstrate that the timing and performance requirements of a uniprocessor avionics system can be met in Ada. Other case studies are planned by the project.

Three technical reports by project members were published during this quarter:

- *Scheduling Sporadic and Aperiodic Events in a Hard Real-Time System* (CMU/SEI-89-TR-11) presents a new algorithm, the sporadic server algorithm, that greatly improves response times for soft-deadline aperiodic tasks and can guarantee hard deadlines for both periodic and aperiodic tasks. The operation of the sporadic server algorithm, its performance, and schedulability analysis are discussed and compared with previously published aperiodic service algorithms.
- *Implementing Priority Inheritance Algorithms in an Ada Runtime System* (CMU/SEI-89-TR-15) documents the specification of the scheduling algorithms. Aimed at compiler vendors, this report describes how to implement a real-time scheduling algorithm (the priority ceiling protocol) in an Ada runtime system.
- When a database system is used in a real-time application, the concurrency control protocol must satisfy not only the consistency of shared data but also the timing constraints of the application. *A Real-Time Locking Protocol* (CMU/SEI-89-TR-18) examines a priority-driven, two-phase lock protocol called the read- or write-priority ceiling protocol, which is free of deadlock. In addition, a high-priority transaction can be blocked by lower priority transactions for at most the duration of a single embedded transaction.

The Sixth IEEE Workshop on Real-Time Operating Systems and Software was held at the SEI on May 11-12, 1989. Eighty-two people attended, and 16 papers were presented. These presentations described promising approaches and work in progress related to real-time software and operating systems, and examined programming language support for real-time systems (Ada and other languages). The workshop was sponsored by the SEI, the Office of Naval Research, and the IEEE Computer Society Technical Committee on Real-Time Systems. The project leader served as program co-chair (together with an affiliate from IBM who is working with this project).

The project provided a one-day tutorial at the Affiliates Symposium in May 1989. The tutorial explained the practical application of analytical real-time scheduling methods. It was aimed at real-time system designers familiar with hard real-time system requirements and designs. Of approximately 120 participants, more than half requested to be kept informed of the project's status.

The project is providing support to the IEEE FutureBus+ effort by having a representative on two IEEE working groups: the Real-Time Working Group and the Operating System Working Group. The real-time scheduling algorithm technology is being incorporated into the next generation IEEE FutureBus+ standard, a backplane bus being developed as part of the Next Generation Computer Resource initiative of the Navy.

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**Distributed Ada
Real-Time Kernel**

The Distributed Ada Real-Time Kernel (DARK) Project has developed a prototype kernel that supports distributed targets. It is currently implemented on the 68020 target, and there is a development version available on VMS. All versions are freely available.

DARK V2.00 was shipped to 11 acceptor sites in June 1989; the 2 that received DARK V1.00 in February 1989, and 9 new acceptor sites. (See page 22 for the names of DARK acceptor sites and more information on DARK transition activities.)

A DARK Formal Demonstration and Workshop was held at the SEI on May 5, 1989. The workshop was held for those organizations that are interested in the implementation and commercialization details of the Kernel. The workshop included detailed technical presentations by the DARK project team and the execution of test cases using the Kernel on the SEI testbed. There were more than 40 participants.

Work continues on adapting the Inertial Navigation System (INS) developed by the SEI Real-Time Embedded Systems Testbed Project. Because the Kernel has its own scheduling mechanisms, the dispatcher task of the INS was removed. The INS is running on all four nodes and is being debugged. The Kernel is currently undergoing final system and performance testing.

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User Interface

The User Interface Project is developing Serpent, a user interface management system. Serpent separates the concerns of the user interface from those of the application, which allows integration of input/output technologies without modifying the functional portion of the application.

Three more companies signed on as Serpent acceptor sites: CADLAB in West Germany; CASET Corporation in San Juan Capistrano, California; and Unisys Paoli Research Center in Paoli, Pennsylvania. Serpent now has five acceptor sites.

Softcopy Mapping System (SMS), a digital mapping system from Lockheed, was integrated into Serpent to demonstrate that different input/output technologies (in this case, SMS and the X Window System) can coexist within Serpent.

The ability to directly manipulate the size and position of X Toolkit widgets was incorporated into Serpent this quarter. Direct manipulation allows the user interface designer to position the size objects directly through interaction with the objects instead of specifying the information textually in terms of screen pixels.

Project members removed Serpent's dependency on OPS83, a production system used for programming expert systems. The project expects that users will adopt Serpent more readily now that they do not need OPS83.

Project members demonstrated Serpent at three major events in May 1989: ICSE, the SEI Affiliates Symposium, and CHI '89. The demonstrations were extremely well received. The project has also received inquiries from people who heard about Serpent from attendees. All people who expressed interest received copies of the Serpent newsletter and registration information for a Serpent workshop in July 1989. More than 200 people were added to the Serpent mailing list, and several are interested in receiving Serpent software. George Washington University, Ohio State University, and Virginia Polytechnic Institute and State University plan to use Serpent in user interface courses in the 1989-90 school year.

The project has been helping the SEI Domain-Specific Software Architectures Project to use Serpent to develop user interface prototypes for Granite Sentry. This is the first use of Serpent with an Ada application.

The Software for Heterogeneous Machines Project is developing tools and a methodology to support applications running on networks of different processors executing concurrent, communicating tasks. The heterogeneous machines targeted by this project have general-purpose processors, special-purpose processors, memory boxes, and switches that can be configured in arbitrary logical networks.

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**Software for
Heterogeneous
Machines**

A comprehensive demonstration of the Durra language and its runtime environment was developed and presented at the SEI Affiliates Symposium. The demonstration consisted of a sequence of examples using several cooperating, concurrent tasks that are configured in and out of the application. The hardware configuration consisted of three workstations connected on an Ethernet local area network.

The implementation of the Durra debugging/monitor task was completed. This task allows the application developer and user to interactively control the execution of the application and to monitor the application during execution.

Project members began to develop a demonstration of Durra using the Inertial Navigation System (INS), a real-time application developed by the SEI Real-Time Embedded Systems Testbed Project. The INS was selected because it has more performance requirements than previous Durra applications or demonstrations.

The project continued to plan the Third Workshop on Large-Grained Parallelism scheduled for October 10-11, 1989, at the SEI. Registration material was mailed to people responding to the initial invitation. Invitations were sent to people doing research or development on languages, tools, and techniques for implementing distributed applications consisting of large-grained, loosely-coupled tasks. The theme of the workshop will be techniques for describing the structure, behavior, and fault-tolerance characteristics of distributed applications.

Scheduling Sporadic and Aperiodic Events in a Hard Real-Time System
(CMU/SEI-89-TR-11)

Implementing Priority Inheritance Algorithms in an Ada Runtime System
(CMU/SEI-89-TR-15)

A Real-Time Locking Protocol
(CMU/SEI-89-TR-18)

Hartstone: Synthetic Benchmark Requirements for Hard Real-Time Applications
(CMU/SEI-89-TR-23)

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**Systems Program
Reports**

April-June 1989

For information on how to order reports, see page 28.

Education

The primary objective of the SEI Education Program is to increase the number of highly qualified software engineers by rapidly improving software engineering education throughout the education communities of academia, government, and industry. To accomplish this objective, the program's projects focus on accelerating the development of software engineering programs in academia and on enhancing opportunities for the continuing education of practitioners.

This quarter, the program signed agreements with two new academic affiliates: Portland State University and the University of Florida. The Academic Affiliates Program provides a means whereby educational institutions can join the SEI in cooperative efforts of mutual interest. These efforts may include work in education, training, research, development, or technology transition.

An article by the director of the Education Program, "The SEI Education Program: The Challenge of Teaching Future Software Engineers," was published in the May 1989 issue of *Communications of the ACM*. The article discusses the purpose and goals of the Education Program and the various projects within the program.

A member of the Education Program, with a former SEI resident affiliate from the Danish Datamatics Centre in Denmark, conducted a tutorial (Formal Methods in Software Engineering) at the 11th International Conference on Software Engineering on May 15, 1989.

The Graduate Curriculum Project and Undergraduate Curriculum Project have been combined to form the Software Engineering Curriculum Project. By combining the two projects, the Education Program will be able to coordinate graduate and undergraduate curriculum development activities more closely and to use its resources more efficiently.

The newly organized project has two purposes: to promote the development of software engineering as an academic discipline, and to promote the establishment of software engineering degree programs throughout the academic community. Project activities will include producing model curricula at undergraduate and graduate levels and providing support materials for a broader range of curriculum topics.

A software engineering ethics workshop was held at the SEI on June 15-16, 1989. Its purpose was to identify important issues and approaches to software engineering ethics. Participants considered how ethics can best be presented to software engineering educators, both to engage their interest and to facilitate teaching ethics topics in their classes. They identified tools and materials educators will need and recommended that the SEI collect case studies for use in the classroom. The workshop was attended by six CMU and SEI participants and six participants from other universities.

Registration is under way for SEI Education and Training Week, which will take place in Pittsburgh on July 18-21, 1989. The week's activities will bring together educators from academia, government, and industry to exchange ideas on all aspects of software engineering education and training. Events will include the Third SEI Conference on Software Engineering Education, the Faculty Development Workshop, and the Workshop on an Undergraduate Software Engineering Curriculum.

The SEI Series on Software Engineering, a joint effort of the SEI and Addison-Wesley Publishing Company, has been established to promote technology dissemination through a series of textbooks and monographs on software engineering. The audience includes both students and practitioners of software engineering. The first book in the series, *Managing the Software Process*, by the director of the SEI Process Program, was published in May 1989.

The Editorial Board for the SEI/Addison-Wesley book series held a meeting on May 14, 1989, in Pittsburgh. The purpose of the meeting was to discuss the direction in which the software engineering field is moving and to set corresponding directions for the book series.

The 1989 SEI Report on Graduate Software Engineering Education (CMU/SEI-89-TR-21) was published. This report includes an update of the project's Master of Software Engineering curriculum recommendations and other information on graduate level software engineering education.

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Video Dissemination

The Video Dissemination Project provides courses on modern software engineering methods to software development practitioners. The project has three series of videotaped courses: the Academic Series, which offers graduate courses for academic credit; the Continuing Education Series, which offers noncredit courses to practitioners in government and industry; and the Technology Series, which provides stand-alone presentations that promote awareness of emerging issues and leading-edge technologies.

Presentation of the Academic Series course, Software Verification and Validation, was completed this quarter. The course covered both the theory and practice of ensuring high-quality software products. It included topics such as quality assessment, proof of correctness, testing, and the limitations of verification and validation methods. The course, which was held in the SEI video studio, was also presented via videotape at the University of New Mexico, East Tennessee State University, and California State University at Dominguez Hills. Thirty-five students received graduate credit for this course.

A second Academic Series course, Software Project Management, was presented via videotape at California State University at Dominguez Hills and Jacksonville State University. Students attending these courses received academic credit.

The first Continuing Education Series course, Software Project Management, was completed this quarter. The course presents a balance of technical content and management topics addressed in traditional software project management courses: planning, estimating, measuring, tracking, evaluating, and directing. It is based on the belief that managers must understand the impact of software engineering disciplines, methods, and technologies on the products and processes they manage. The course, which consists of three mini-courses of 2.5 days each, was attended by 23 students representing 12 government and industry organizations. Students who successfully completed course requirements received continuing education units.

The second offering of the Software Project Management course began at the SEI this quarter, with 25 students enrolled. Twelve of these students are enrolled as future tutors of the course. They will attend a one-week orientation session in July 1989 at the SEI, where they will receive help in tailoring the course to meet the educational requirements of their particular organization.

Software and Some Lessons Learned from Engineering, the first Technology Series videotape, was released. The lecture, by the leader of the Software Architecture Design Principles Project, discusses the path that software engineering must take to become a legitimate engineering profession. The videotape was distributed, without charge, to participants in the Academic Series and to tutors in the Continuing Education Series. Additionally, copies of the videotape were purchased by Mellon Bank, Telos Federal Systems, and Texas Instruments.

The Advanced Learning Technologies (ALT) Project is using hardware and software technologies to teach software code inspections. Interactive, technology-intensive training can be distributed economically to a broad audience and can provide an effective learning experience.

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**Advanced Learning
Technologies**

The project, which is a beta site for Intel's Digital Video Interactive technology, began conversion to Intel's new system software. The first audio and video tape was sent to Intel for compression onto a CD-ROM. In addition, project members began to enter and format articles that will be available online in the system resource library, which is a collection of supplementary readings on code inspections.

Apple's Advanced Technologies Division invited project members to present a talk to their artificial intelligence research group. The presentation, "Groundwork for a Knowledge Navigator Agent: Intelligent Digital Video to Create Simulated Persona," was well received. As a result, a group at Apple is proposing an intelligent digital video tutor for network systems analysis based on the ideas developed for the ALT Project.

With the assistance of the University of Nebraska, the project will conduct the Workshop on Design and Development of Intelligent Tutoring Systems and Interactive Digital Video on July 20-21, 1989, in Pittsburgh. This workshop provides an opportunity for faculty members and trainers to become aware of advanced learning technologies and strategies for effectively incorporating current theories of cognitive psychology into design of educational media.

Project members gave a demonstration of the ALT system at the 11th International Conference on Software Engineering held in Pittsburgh. Feedback on the project demonstration was positive, and there was interest by some attendees in acquiring the product.

The Software Engineering Video Network (SEVN) Function provides the facility, equipment, and technical expertise to support the audio/video production requirements of the SEI. The SEVN studio is primarily used to tape courses for the Video Dissemination Project, as well as for the videotaping and editing activities of the Advanced Learning Technologies (ALT) Project. The SEVN facilities are also used by other SEI programs and by Carnegie Mellon.

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**Software Engineering
Video Network**

The SEVN facility was used to videotape one Academic Series course for the Video Dissemination Project and five mini-courses for the project's Continuing Education Series.

The SEVN, in collaboration with the ALT Project, produced a videotape of the ALT system, which project members now use when they demonstrate the system.

During this quarter, the SEVN facility was rented by other departments of Carnegie Mellon for a total of 100 hours.

1989 SEI Report on Graduate Software Engineering Education
(CMU/SEI-89-TR-21)

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**Education Program
Reports**

April-June 1989

For information on how to order reports, see page 28.

Ada & STARS Support

As Ada matures and its use becomes more common within the mission-critical computer resource (MCCR) community, users will be faced with the benefits and problems of adopting more disciplined approaches to software engineering. The goals of the Ada and STARS Support effort are to remove technical and managerial impediments to the adoption of Ada, to support the DoD STARS (Software Technology for Adaptable, Reliable Systems) Program in technology development and transition efforts, and to explore the advantages and disadvantages of new software engineering approaches and paradigms made possible by Ada language features.

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**Domain-Specific
Software Architectures**

The Domain-Specific Software Architectures Project provides technical guidance to DoD program offices in applying innovative, model-based software engineering solutions to the problems that characterize an application domain. The project is working with the Granite Sentry Program Office on part of the replacement for the NORAD system in Cheyenne Mountain, the AWIS Program Office in the development of the World-Wide Military Command and Control Information System, and the Advanced Millimeter-Wave Seeker Program Office in the redesign of the Maverick air-to-ground missile seeker from infrared sensing to millimeter-wave radar. In each effort, the project takes an active role in the design and development of the system.

This quarter, project members completed 80% of the documentation for the Message Translation and Validation (MTV) model. The MTV model provides the capability to convert between different message representations and checks all representations for validity. The documentation describes different views of the MTV model based upon the intended audience. The views can be summarized as: an architectural component for reference at the design level; detailed application notes for users of the model solution; and detailed implementation notes for showing how the model solution works. The MTV documentation will be used as a model to develop a prototype handbook for the C3I domain.

In conjunction with Hercules Defense Systems, work progressed on the design and implementation of the signal processor software for the Maverick missile seeker. The critical design review showed that the project's object-oriented design methodology results in a design that is easy to understand, document, and review. The changes to the requirements specification helped to improve the design by allowing more design flexibility and assisted in generating more clearly defined requirements that were easier to trace throughout the software life cycle. Lessons also were learned about the effect of the strong typing of Ada to the design.

Also during this quarter, the project worked with key AWIS design team members to help them understand the benefits of a modeling approach for solving some of the recurring problems associated with software development. Project members reviewed the functional description documents for several AWIS sites and began developing model solutions to such recurring problems as the man-machine interface, the report generator, and the Ada/SQL application-to-database interface.

The Binding of Ada and SQL Project, initiated at the request of the Ada Joint Program Office (AJPO), has investigated the problem of binding the Ada programming language with the Structured Query Language (SQL) database language. The solution to this problem was the specification of the SQL Ada Module Extensions (SAME), an interface that permits an application program written in Ada to access and manipulate data controlled by a database management system (DBMS) using SQL.

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**Binding of Ada
 and SQL**

This quarter, project members began distributing the source code of the SAME standard packages. These packages consist of more than 1500 lines of Ada code that support the SAME methodology.

A report that describes the SAME method was released. *Guidelines for the Use of the SAME* (CMU/SEI-89-TR-16) contains a complete description of the SAME, including the motivation for its development. This report is intended for application developers and technicians creating Ada applications for SQL database management systems. Sections are included that describe decimal arithmetic and dynamic SQL. An order form for the SAME standard packages is also included in the report.

Also completed this quarter was the conversion of the SAME standard packages to DB2. The packages can now run on IBM systems under the MVS-TSO operating system with an Intermetrics Ada Compiler and the DB2 database.

At the meeting of the March 1989 SAME Design Committee, the project began developing the Abstract Module Description Language (AMDL), a language that is used to automatically construct the Abstract Module. The Abstract Module provides the interface between the SQL statements and the Ada application. Currently, this interface is manually implemented. A prototype processor for the language is also being developed by the project. Project members met with the International Standards Organization (ISO) Working Group 9 to discuss the possibility of making the AMDL a standard.

The Ada Joint Program Office (AJPO) has decided that a revision to the the Ada language standard is required to maintain it as a standard (ANSI/MIL-STD-1815A). The purpose of this project is to identify and evaluate potential areas for revising the Ada standard based on the experiences of software developers and compiler implementors. This project is providing an organizational framework to help guide revision activities.

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**Study and Analysis
 for Ada 9X**

The Third International Workshop on Real-Time Ada Issues, sponsored by the SEI and the Office of Naval Research in cooperation with Ada UK and ACM SIGAda, was held on June 26-29, 1989, at Nemacolin Woodlands in Farmington, Pennsylvania. The purpose of the workshop was to explore potential Ada language revisions that will make the revised version of Ada more suitable for real-time and distributed applications. Attended by 33 people, the workshop provided an opportunity for users to discuss the features of Ada that should be revised, those that should be added, and the features that should not be changed. A proceedings will be published by SIGAda later in 1989.

Suggestions for technical tasks needed to revise the Ada standard were delivered to the Ada 9X project manager at Eglin Air Force Base, Florida. In addition, work also continued in these areas: extended character set, shared variables, reuse language issues, and mathematics libraries.

Guidelines for the Use of the SAME
 (CMU/SEI-89-TR-16)

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For information on how to order reports, see page 28.

Technology Transition

The Technology Transition Program is the focal point for SEI transition efforts. The program works with other SEI programs to match problems and solutions in the DoD software community.

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Technology Application

The Technology Application Function provides a link between DoD mission-critical application domains and ongoing SEI technology evaluation and development efforts. The goal is to identify technologies useful in a particular application domain and to assist in their maturation by working with specific clients to provide product transition and direct support.

The Distributed Ada Real-Time Kernel (DARK) is maturing rapidly, and the number of acceptor sites has increased from 2 to 11. The firms currently evaluating the DARK prototype include: Wichita State University/Boeing Military Airplane; Lockheed (3 separate programs); General Dynamics; Hughes Aircraft; Ferranti International; Schultz Engineering; The Analytic Sciences Corporation; Westinghouse Electronic Systems Group; and the Naval Weapons Center at China Lake. The project hosted a one-day workshop at the SEI in May 1989 targeted at organizations interested in commercializing DARK. The DARK Project continues to seek firms interested in the commercial aspects of this technology.

The Air Force Contract Management Division (AFCMD) Annual Joint Executive Conference (JEC) was held on May 16-18, 1989, in Albuquerque, New Mexico. Chief operating officers from 27 aerospace firms attended. The SEI briefed the attendees on the Executive Software Issues Workshop and related activities sponsored by the SEI.

The SEI has organized three groups to work on issues related to the ongoing Air Force Systems Command (AFSC) Software Action Team. The team is coordinating the actions and responses of the AFSC to a recent Air Force-wide broad area review on software. These efforts, involving several initiatives within the Air Force, were briefed to industry representatives at MITRE on June 23, 1989. Each of the three SEI groups, addressing topics in software acquisition and development processes as well as manpower, personnel, and training issues, is being coordinated by a member of Technology Application.

Work began with the Air Force Wright Research Development Center (WRDC) on the Pave Pace Program. Pave Pace is an effort to define the next generation of avionics systems as a follow-on to the Pave Pillar Program. The SEI is supporting WRDC by evaluating the state of avionics software and system development technology, investigating existing R&D activities that would improve avionics development, and assisting WRDC in putting together an avionics technology development plan for critical technologies to be developed over the next five to ten years. During this quarter, the effort was established and organized, and the first quarterly review was held with WRDC on June 27, 1989.

The Affiliate Relations Function establishes and maintains SEI relationships with industry organizations. Affiliate Relations also negotiates and places, with the cooperation of the SEI Joint Program Office, government and industry resident affiliates at the SEI. The SEI Education Program manages academic affiliates and visiting scientists from academia.

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Affiliate Relations

The fourth SEI Affiliates Symposium was held on May 2-4, 1989, at the SEI and two nearby locations in the Oakland section of Pittsburgh. The annual symposium is a key forum for exchanging information among software communities from industry, government, and academia. The symposium highlighted the state of software engineering practice and technology as well as specific SEI projects. Lloyd K. Mosemann, Deputy Assistant Secretary of the Air Force for Logistics, delivered the keynote address, entitled "Software Engineering and Beyond: The People Problem." The symposium was attended by 358 people from affiliate organizations: 248 from industry, 78 from government, and 32 from academia. One day of tutorials and workshops was followed by two days of briefings and conference sessions.

Nine new industry affiliates signed information exchange agreements during this quarter: Hughes Aircraft Company, Radar Systems Group-Advanced Programs Division; Insight Industries; Medtronic; Mikros Systems Corporation; P-Cube Corporation; Rockwell, Collins Defense Communications; SAIC, Military Sciences Group; SOPHSYS; and the Software Productivity Consortium.

Three new resident affiliates joined the SEI this quarter. A senior member of the technical staff from GTE began working with the Real-Time Embedded Systems Testbed Project. A senior software engineer from GE Aerospace and a captain from Gunter Air Force Station both began working on software reuse. A resident affiliate from IBM, who was working on the Real-Time Scheduling in Ada Project, concluded his term of residency. As of June 30, 1989, 16 resident affiliates are working at the SEI: 7 from industry and 9 from the Services and government agencies.

GTE's Quality Managers Group visited the SEI in June 1989. The agenda predominantly addressed software process improvement, quality, and technology transfer issues.

The Transition Training Function provides training development services to support transition activities of SEI technical projects. In addition, the function provides training on managing the organizational changes associated with technology transition, and consulting services to customers on software engineering training issues.

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Transition Training

The process self-assessment course underwent revision and a further pilot test at the SEI in May 1989. Developed in conjunction with the Software Process Assessment Project, the course is in final revision and is scheduled for delivery in the fourth quarter of 1989.

A one-day tutorial on planning for technology transition was developed and presented twice at the SEI Affiliates Symposium and a third time at the quarterly executive meeting at the Government Information Systems Division of Planning Research Corporation in McLean, Virginia. The tutorial is a distillation of the three-day course on managing technological change offered by Transition Training. In April 1989, the three-day course was taught at Contel Federal Systems to a class representing a cross-section of that organization.

Transition Training staff helped subject-matter experts at SPAWAR to develop six of ten units for a course on software acquisition. The course will be pilot-tested at SPAWAR in September 1989.

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**Information
Management**

The Information Management Function develops, edits, publishes, and maintains information relevant to the mission and accomplishments of the SEI.

Several publications were issued during the quarter. The June 1989 issue of *Bridge*, the SEI magazine, covers the SEI Affiliates Symposium. The first issue of *Serpent News*, a newsletter about the User Interface Project, discusses the alpha release of the Serpent software and documentation. A brochure for Education & Training Week describes the week of activities (July 18-21, 1989) that the SEI Education Program is sponsoring.

The SEI library added 130 book titles and 6 periodicals to its collection and 250 documents to its database during this quarter. The collection now comprises 2430 book titles and 226 periodicals. The database contains information about 3050 documents germane to software engineering. The library collection is available through the OCLC interlibrary loan network, which provides access to 3400 participating libraries in the U.S. The SEI library also distributes SEI technical reports to 27 libraries, 10 of which send their organization's reports to the SEI library.

The SEI librarian gave an invited presentation on "The Library of the Future" to the IEEE Board of Governors while they were visiting Pittsburgh during the 11th International Conference on Software Engineering.

Three members of Information Management gave two presentations at the International Technical Communications Conference in Chicago. One presentation, "Design in the High-Tech Environment," discussed how the SEI uses computers and other publishing equipment to solve design problems. This presentation will be used in the Summer Design Program at Carnegie Mellon in July 1989. The other presentation, "Strategies for Persuasive Editing," provided strategies, such as using "lessons learned," that help editors and technical authors work together effectively. This talk will be presented to technical writing students at Carnegie Mellon in the fall.

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Empirical Methods

The Empirical Methods Function supports transition management of SEI technology projects by providing market research methods and materials, conducting surveys, and evaluating or validating products and events of SEI projects.

Protocol analysis and usability studies are being conducted on the Process Program's refinement of the process assessment questionnaire. These analyses will be completed in July 1989, and pilot testing will occur in the fall of 1989.

The SEI received a request from the Air Force Systems Command to collaborate with ESD and MITRE to conduct a two-phased study of U.S. software capacity. The near-term effort, which began in June 1989, is to assess the nation's capability to produce software for the DoD. This study will be completed in October 1989. A project to develop a model and methodology to use on a continuing basis to assess the capacity of the nation's software industry will begin in October 1989 and may continue for three to five years. Both efforts will involve study of the supply and demand of software personnel in government and industry for both commercial and military sectors. Empirical Methods is coordinating the study, which is staffed with a team of faculty from Carnegie Mellon, Purdue, and the University of Arizona.

Adoption of Software Engineering Innovations in Organizations
(CMU/SEI-89-TR-17)

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For information on how to order reports, see page 28.

Computing Facilities

Computing Facilities is responsible for the SEI computing environment, which provides a diverse mix of hardware, software, and other services to support a variety of individual and project needs. Additionally, Computing Facilities provides computing acquisition support (including consultation, negotiation, and coordination) and assessment of new technologies in the marketplace.

..... A secondary node for receiving electronic mail from remote sites was installed. Previously, whenever the SEI's primary e-mail node was down, the flow of e-mail was interrupted. With this new system in place, remote sites that cannot connect to the primary node automatically try the secondary node. As a result, mail service with other sites is uninterrupted.

Computing Facilities is working to prevent unauthorized entry by tightening the gateway and by monitoring file transfer and login access. A computer program routinely reviews passwords to find those that can be easily guessed or broken.

The way the SEI implements databases is being coordinated and consolidated. For instance, during a recent conversion of an existing Informix database to INGRES, generic system utilities were developed for implementing INGRES on all SEI workstation/terminal types and for integrating it with NFS (network file system). Computing Facilities also began to develop requirements for central data management at the SEI.

CERT Coordination Center

The purpose of the Computer Emergency Response Team Coordination Center (CERT/CC) is to supplement existing mechanisms by which informally organized experts deal with and prevent computer emergencies. The CERT/CC at the SFI supports two different communities: Internet users, and developers of technology that is available on the network, such as UNIX and networking software. The services provided by the CERT/CC generally fall into these categories:

- Provide a dependable and trusted 24-hour-a-day point of contact for security issues.
- Maintain a reliable and highly secure repository of information for team members.
- Provide rapid communication during emergencies.
- Maintain close ties with research in the area of trusted systems to improve the security of existing systems.
- Raise constituents' awareness of security issues and assist individual organizations in improving the security of their systems.

Project members made presentations at the following conferences: the Computer Viruses '89 Conference sponsored by the Computer Security Institute, the USENIX 1989 Summer Technical Conference, and the SUN Microsystems Western Users' Group Conference. As a result of these presentations, the CERT/CC enlarged its base of contacts to more than 400 people in the client communities and strengthened its working relationships with the technical community and organizations involved in computer security.

The CERT/CC, in cooperation with the National Institute of Standards and Technology, is organizing a Computer Security Incident Response Workshop, to be held at the SEI on July 31-August 1, 1989. The purpose of the workshop is to identify the problems involved in the operation of computer security incident response centers and to discuss solutions. The workshop will focus on incident handling, vendor relations, clearinghouse activities, communications, legal and investigative issues, constituency relations, research, threat modeling, and external issues that affect the operation of response centers.

For More Information

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How to Order SEI Publications

To order an SEI publication, send a written request accompanied by a preaddressed mailing label to:

Software Engineering Institute
ATTN: Publications Requests
Carnegie Mellon University
Pittsburgh, PA 15213-3890

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How to Get the SEI Magazine

To be added to the *Bridge* mailing list, write to:

Software Engineering Institute
ATTN: Bridge Mailing List
Carnegie Mellon University
Pittsburgh, PA 15213-3890

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How to Become an SEI Affiliate

For information on opportunities for affiliation, contact:

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How to Get Additional Information

For further information about the SEI, contact:

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