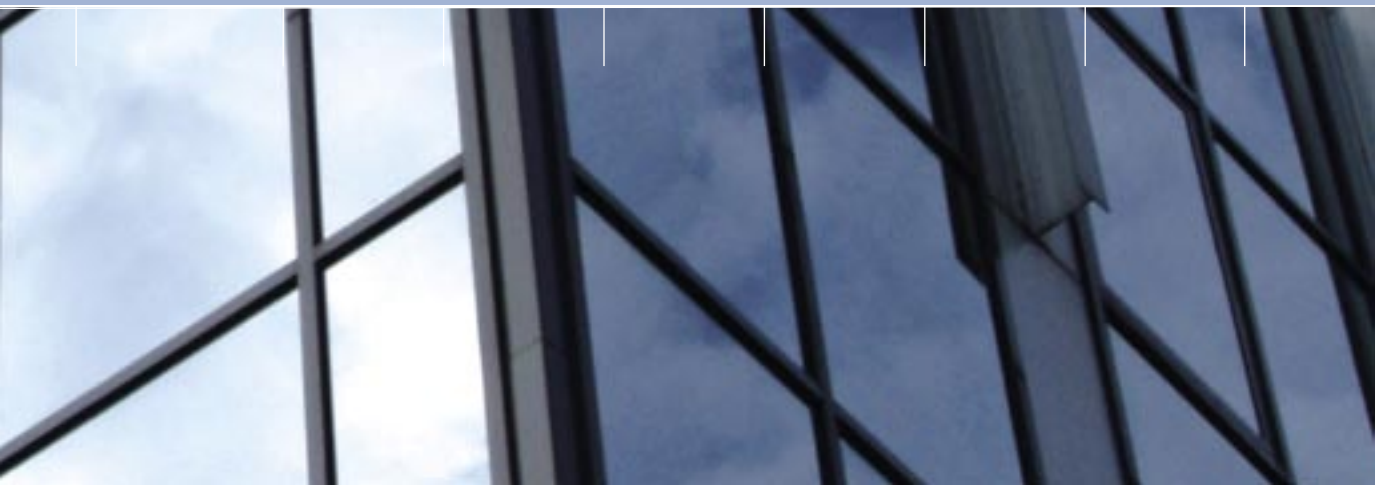
Carnegie Mellon
Software Engineering Institute

ANNUAL REPORT FY 2004 20/20 IMPACT / VISION

The Carnegie Mellon® Software Engineering Institute (SEI) is a federally funded research and development center.

The SEI provides the technical leadership to advance the practice of software engineering so that software-intensive systems can be acquired and sustained with predictable and improved cost, schedule, and quality.



▶ SEI Director and Chief Executive Officer Paul D. Nielsen

> Software affects us all. Today, more than ever, we need software that is built with quality, software that is developed on time and on budget, and software that is usable, maintainable, and evolvable. Software is bringing the 21st century to life.

The Software Engineering Institute: 20 Years of Impact, a Vision for Tomorrow

Since 1984, the Carnegie Mellon University Software Engineering Institute (SEI) and its men and women have served the nation by advancing software engineering principles and practices and by serving as a national resource in software engineering, networked systems survivability, and process improvement.

As the information revolution has continued its relentless advance, software has continued to grow in importance and impact, not only in defense systems but also in transportation, finance, medicine, entertainment, and all other aspects of our lives.

Software affects us all. Today, more than ever, we need software that is built with quality, software that is developed on time and on budget, and software that is usable, maintainable, and evolvable. Software is bringing the 21st century to life.

In this year's annual report, we take a retrospective look at the tremendous contributions the SEI has made in many areas, including software process improvement, network security and survivability, software architecture and product lines, real-time systems, risk management, and software engineering education.

We also look at the past year and provide the latest on our work in these and newer areas, such as the integration of software-intensive systems, the development of systems from components whose quality and performance are trustworthy, and the improvement of software acquisition skills in the U.S. Department of Defense (DoD) and other government agencies. Finally, we look ahead, with statements from our senior technical staff about their visions for software engineering in the coming decades.

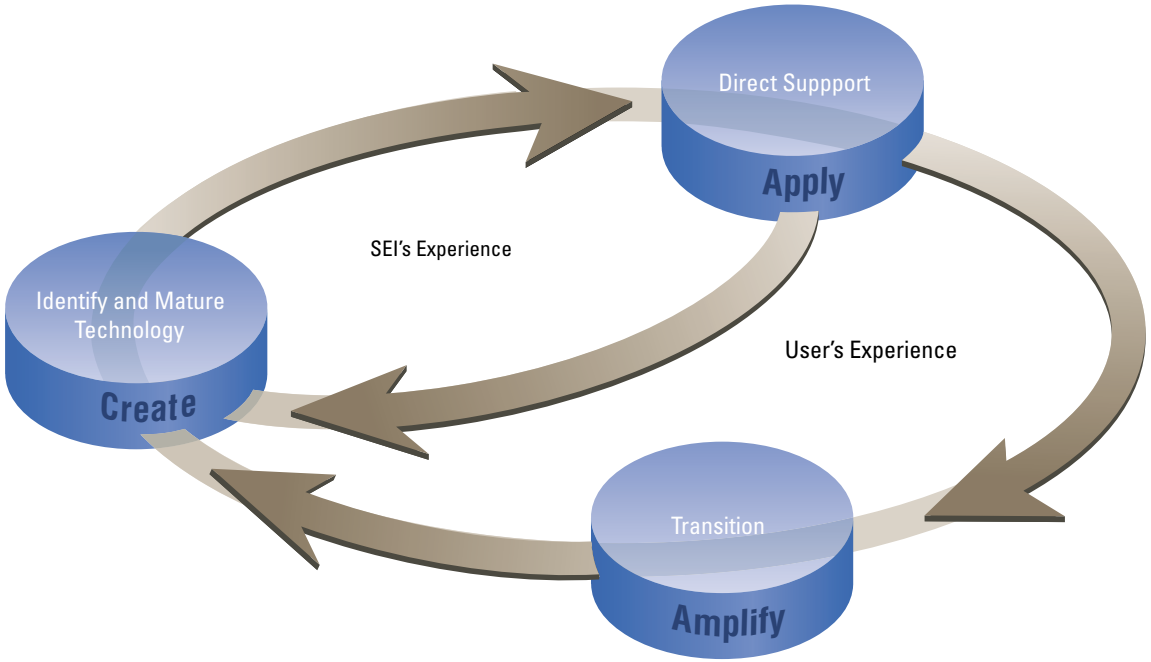
As in 1984, the SEI today operates as a federally funded research and development center, with major funding from the DoD. The SEI also works closely with industry and academia through collaborations.

As a part of Carnegie Mellon University, which is well known for its highly ranked programs in computer science and engineering, the SEI operates at the leading edge of technical innovation.

We hope that what you see in this year's annual report will inspire you to work more closely with the SEI—for example, by examining the research and methodologies described at our Web site (www.sei.cmu.edu), taking an SEI-licensed course, or pursuing research collaborations with our technical staff. We thank you for reading.

Paul D. Nielsen
Director and Chief Executive Officer
Software Engineering Institute

The SEI's Strategic Approach



Create
The SEI works with the research community to help create and identify new and improved practices. The SEI creates and identifies emerging or underused solutions to significant and pervasive software engineering problems and develops these solutions so that they can be applied by software developers and acquirers to improve their software engineering practices. The SEI enters into cooperative research and development agreements with industry and academia to test new and emerging technologies.

Apply
The SEI works with leading-edge software developers and acquirers to apply and validate the new and improved practices. Staff members help the DoD solve specific software engineering and acquisition problems by applying these practices. SEI direct support is funded through task orders for government work.

Amplify
The SEI works through the global community of software engineers to amplify the impact of the new and improved practices by encouraging and supporting their widespread adoption. The SEI works closely with DoD engineering organizations. In addition, the SEI offers continuing education courses based on matured, validated, and documented solutions, and licenses the packaging and delivery of new and improved technologies.

1984

With the support of U.S. Rep. John Murtha of Pennsylvania, Congress and the U.S. Department of Defense award the contract for the Software Engineering Institute to Carnegie Mellon University in Pittsburgh, PA.

1985

The first SEI Symposium, which describes the SEI's program of work, is held in Pittsburgh and attended by representatives from about 100 DoD and commercial organizations. Attendance reaches 1,200 in 1997. Conferences focusing on specific topics eventually replace the symposium.

The SEI initiates a resident affiliate program, bringing industry experts to the SEI for short-term assignments. To date, more than 100 affiliates have worked on projects with the SEI.

1986

An SEI team led by Watts S. Humphrey, in conjunction with the Air Force and the MITRE Corporation, develops a questionnaire to analyze software processes based on maturity. This is the first step in developing the Capability Maturity Model® approach to process improvement.

Larry Druffel is named director of the SEI. Druffel's previous positions included director of computer systems and software (research and advanced technology) in the Office of the Secretary of Defense.

The SEI opens an office in Arlington, VA, near the Pentagon. Today there are 33 employees at this office.

20 Years of Software Engineering Impact

What was the matter with software?
By 1982, the U.S. Department of Defense (DoD) needed an answer to the question and a solution to the problem that software was too costly and was hardly ever delivered on schedule—if at all.

"The digital revolution got under way in the 1950s," recalls the SEI's Tom Brandt, who in 1984 was a U.S. Air Force major general. "By 1960, we were crossing into the more common use of digital environments in systems. Therefore software, which was an enabling technology, began to come into its own. Throughout the decades of the '60s and '70s, there was an ever-increasing dependency on software in large defense systems. By the time the '70s were ending, we had good insight into the difficulty that was presented."

The difficulty included escalating software costs as a proportion of spending on computing systems—almost 90%, or $11 billion, in 1985—as well as poor productivity and a growing list of failures related to software. One example, the Sergeant York anti-aircraft gun, was finally canceled because of software problems after 14 years and $1.8 billion of investment.

In 1982, the DoD launched a software initiative calling for three deliverables:

1. a new program: Software Technology for Adaptable, Reliable Systems, or "STARS";
2. a higher order computer language for defense systems, known as Ada; and
3. a Software Engineering Institute, which would be a federally funded research and development center (FFRDC) modeled after Lincoln Laboratory, the Jet Propulsion Laboratory, and the Applied Physics Laboratory. The SEI would improve the practice of software engineering as an emerging, but nascent, discipline.

The contract for the SEI was opened to competitive bidding—a first for an FFRDC. Nico Habermann and Allen Newell of Carnegie Mellon University's computer science department—two of the most respected academics in the field—lobbied the university administration to pursue the contract aggressively. "They said that if there's going to be an SEI as an FFRDC, then we have to go for it," recalls Angel Jordan, then provost of the university.

Jordan assembled a team from the Department of Computer Science to begin work on the proposal and enlisted the support of Pennsylvania Gov. Richard Thornburgh and the state's entire Congressional delegation, particularly U.S. Rep. John Murtha. The final multi-volume proposal covered everything the team could think of, from the institute's technical program to its financial structure.

"Carnegie Mellon had one of the top computer science programs in the world and a proposal that clearly demonstrated a long-term vision for how the institute would impact the DoD and the software industry," Murtha recalls. "It was a natural fit for the SEI, and history has shown that it was the right decision."

During the two years that the SEI building was under construction, the institute was housed on South Aiken Avenue in Pittsburgh's Shadyside neighborhood, about a mile from the university campus. The institute originally employed 55 people, including 12 managerial staff members and 19 researchers. Among this group were several "visiting scientists," experts from government, academia, and especially industry, who brought significant technical capabilities and practical experience to the SEI's research team. The SEI continues to employ visiting scientists; 88 were on staff in fiscal year (FY) 2004.

Building a Research Team

In the first years, the SEI had to find its way. "One of the real challenges in those early years was determining what technical areas the SEI would work on," says Brandt, who in 1986 became vice commander of the Air Force Electronic Systems Division and was executive agent for the SEI. He was responsible for the Joint Program Office that oversaw the operation of the SEI. Soon after his retirement from the Air Force in 1989, Brandt became a full-time member of the SEI staff.

Within the first two years, the SEI settled on six program areas: technology identification and assessment; the nature of the transition process; education; reusability and automation; system design, construction, and integration; and reasoning about software engineering processes.

The institute also had to attract some of the best people in the field, despite having no record of accomplishments. One illustration of this challenge was that people were sometimes hired to work on a project but almost immediately switched to another project. Len Bass, for example, joined the SEI in 1986 to develop an online information system but instead worked on a user interface management system. John Goodenough expected to work on software reuse but was convinced by Lui Sha to work on real-time systems, which included rate monotonic analysis, a method for understanding the timing behavior of real-time systems.

> "We let good people define their roles, while we provided the strategic context and let it fit into the overall scheme of what we were trying to do."

Watts S. Humphrey agreed to join the SEI with no particular job description other than "a handshake agreement" to start a program to investigate software development processes. "My attitude was, let's go hire the best we can get, have them help us figure out what to do, and make opportunities for them," says

1987

Under the leadership of Norm Gibbs, the SEI develops a model curriculum for a Master of Software Engineering program and degree. It is adopted by Carnegie Mellon University and other universities nationwide.

The SEI publishes the *Ada Adoption Handbook: A Program Manager's Guide* by John Foreman and John Goodenough and distributes 2,000 copies of the first edition. Version 2 is published in 1992.

The SEI publishes the first technical reports describing the Capability Maturity Model® (CMM®) for Software and a methodology for assessing the process maturity of defense contractors.

The SEI moves into its current home on Fifth Avenue in Pittsburgh's Oakland section.

1988

At the urging of the Defense Advanced Research Projects Agency (DARPA), the SEI creates the first computer emergency response team after an Internet worm cripples 10% of computers on the Internet.

The SEI hosts the first Software Engineering Process Group (SEPG℠) workshop. This evolves into the SEPG conference, which draws an annual attendance of 2,000 and inspires similar conferences in Europe, Australia, and Latin America.

Larry Druffel, who was SEI director from 1986 to 1996. "When you get world-class technical people, you have to give them strategic direction, but you also have to let them follow the interests that excite them. We would let good people define their roles, while we would provide the strategic context and let it fit into the overall scheme of what we were trying to do, based on our understanding of the customer's needs and evolving technology."

Clyde Chittister joined the SEI in 1985 after hearing a talk by Nico Habermann, who had served a dual role as the first director of the SEI and head of Carnegie Mellon's computer science department. "The SEI was trying to put together an interdisciplinary group: not only researchers from the academic environment but also people from industry with experience building and fielding software-intensive systems. Academia, industry, and government would work in a collaborative way," says Chittister, who had been with Brown Boveri Control Systems. "The academic community was very open. The belief was that we should look at things in a lot of different ways and not be narrow in our view of what technology would make the most impact."

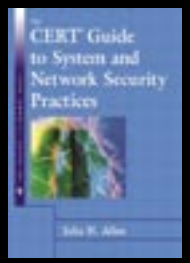
"The academic community was very open. The belief was that we should look at things in a lot of different ways and not be narrow in our view of what technology would make the most impact."

In 1985, the SEI started a program in which sponsoring organizations placed "resident affiliates" with the institute for periods ranging from six months to four years. "The resident affiliate program had multiple purposes," Chittister says. "It enhanced the capabilities of the institute by bringing in domain knowledge and practical experience the staff didn't possess. Affiliates would also act as champions. When they went back to their organizations, they took their knowledge about the SEI and their experience working here. It allowed the SEI as an organization to become better known in that community." Since 1985 about 100 technical experts have joined the SEI as affiliates, including 28 affiliates currently working on projects.

Soon the team and the agenda began to gel. Development of a curriculum for a Master of Software Engineering degree, led by Assistant Director Norm Gibbs, succeeded so well that it was declared a success and retired. "People were not learning the right things in computer science programs," says Len Bass, who had been chair of the Department of Computer Science at the University of Rhode Island before joining the SEI. "They were focused on algorithms and the mechanics to make the computer go. The software engineering program focused much more on organizational and business issues."

Gibbs, who died in 2002, told *Datamation* magazine in a 1986 interview that "a software engineer's training should be analogous to a master's degree in business administration. An MBA is not an in-depth exercise in business, but it's a collection of disciplines that are important in business. Similarly, software engineers need skills from the fields of computer science, hardware design, project management, psychology, and economics." Gibbs's vision has been realized at Carnegie Mellon in the Master of Software Engineering program and in similar programs at other universities. The SEI, however, does little work in this area today—an example of the SEI's strategy of terminating work when there is sufficient community involvement to sustain the work without direct SEI involvement. Bass says, "It went out of business here because it was so successful."

The SEI also established a program in risk management. "Congressman Murtha funded the SEI specifically to come up with a set of techniques for how to identify, quantify, and



1989

Addison-Wesley begins publication of the SEI Series in Software Engineering. Today the series comprises more than 30 volumes on a wide range of software engineering topics.

1990

With funding from Congress, the SEI establishes a program in risk management to identify, quantify, and develop mitigation strategies for risks on weapons system software.

1991

The SEI publishes version 1.0 of the CMM for Software (SW-CMM). More than 30,000 people are eventually trained in the principles and techniques of CMM, and more than 2,400 organizations are assessed on the five-level CMM scale. The SW-CMM is upgraded to CMM Integration (CMMI) in 2000.

develop mitigation strategies for risks on weapons system software," says Chittister, who worked on the project. "His question was, 'What are 10 questions I should ask when programs come before Congress?'" The risk program produced courses, reports, and a book on continuous risk management. Although it is no longer an active program at the SEI, Chittister says the work on risk management has been propagated to SEI programs in software architecture and network security and is part of the methodology for independent technical assessments that the SEI conducts on government projects.

Other projects that were thought to be major initiatives were either reconsidered or lost their support at the DoD. Mario Barbacci, one of the SEI's original technical staff members, recalls that an early SEI focus was to be intellectual property—specifically the problem that DoD software contractors maintained ownership of their intellectual property. This meant that the DoD would have to continue paying a contractor for all maintenance, changes, and upgrades to a software-intensive system. "The company had a contract for life," Barbacci says. One of the DoD's first requests to the SEI was to analyze the way software contracts were written and to try to find a better way. "That's why we had lawyers on the staff in the early days," he says. "They did a very good job. Reports were created that went to Congress."

Some projects have had a major, but relatively quiet, impact. "Our real-time program was a home run," says Druffel, who is now president and CEO of South Carolina Research Authority (SCRA), a non-profit research and development (R&D) corporation that applies advanced technology to improve competitiveness. "The SEI brought a mathematically disciplined approach to real-time systems through the work of John Goodenough, Lui Sha, and John Lehoczky with rate monotonic analysis and the Simplex™ architecture for real-time systems. Those things don't get the play that they should get."

CERT: A Strategic Opportunity

The SEI is best known for two major innovations: the development of the Capability Maturity Model framework for software process improvement and the creation of the first computer emergency response team, "CERT," to study, track, and remediate network attacks and vulnerabilities.

> On December 7, 1988, DARPA issued a press release announcing the existence of CERT. "The phone rang for the first time that night. We had six hours of idle time before we got the first call!"

Druffel says that the SEI's long-term plans called for research into computer and network security. "Security was a strategic area we wanted to pursue. CERT wasn't the way I would have chosen, but given the situation, it was a way to get into it. Sometimes you have to be opportunistic in a strategic way."

The situation that pushed the SEI into a leadership role in computer security was the so-called "Internet worm." In 1988 there were about 88,000 computers connected to the Internet. That November, a graduate student at Cornell University released a program that clogged and crippled the network. Computer scientists around the country rushed to understand and solve the problem—a process that included informal communication with each other. Within days, this ad hoc group had contained the problem and told the world how to correct it. "It was pretty amazing," recalls the SEI's Richard Pethia, who now heads the Networked Systems Survivability program at the SEI and is one of the world's foremost experts on network security and survivability. "People really worked effectively together."

1992

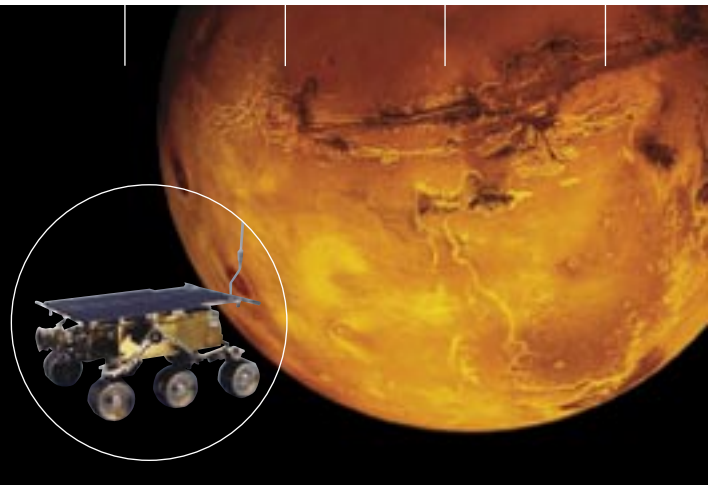
The technical report *Introduction to Software Process Improvement,* by Watts S. Humphrey, includes recommendations for widespread dissemination of software process improvement practices.

The SEI publishes six technical reports providing guidance on how to precisely define software measures, a watershed for SEI work in this area. In 1995, the SEI initiates work in software engineering measurement and analysis.

1993

The SEI introduces the SEI Personal Software Process℠ (PSP℠) methodology, by which individual software engineers use disciplined, repeatable practices to produce software.

A Practitioner's Handbook for Real-Time Analysis: Guide to Rate Monotonic Analysis (RMA) for Real-Time Systems describes the use of RMA techniques, which become widely adopted and are credited with helping NASA restart the Mars Pathfinder in 1998 after a system shutdown.



The federal government wanted to make sure that future problems would be handled just as effectively. "There was a lot of debate in Washington as to whether or not there should be a centralized approach or a decentralized one, and if industry or government should do it," Pethia says. "Finally, the director of DARPA said, 'Well, in lieu of all this discussion, which may never end, let's just do something.'"

DARPA contacted Druffel at the SEI and said that the Defense Department wanted to start a computer emergency response team. Druffel tapped Pethia, who had been developing a customer service group to market the SEI's products and services, to lead the effort. "There was a lot of internal debate," Pethia recalls. "A lot of people thought that this type of function didn't belong in an R&D facility, but Larry decided to go ahead with it." On December 7, 1988, DARPA issued a press release announcing the existence of CERT. "The phone rang for the first time that night," Pethia says. "We had six hours of idle time before we got the first call!"

The phone has not stopped ringing since. Today, the far-reaching CERT® Program includes the CERT Coordination Center (CERT/CC). The CERT/CC collects data and responds to network security incidents and vulnerabilities; since 1988, it has examined more than 16,000 reports of software vulnerabilities, published almost 1,300 notes on vulnerabilities, and issued nearly 500 security alerts. In addition, the CERT Program conducts research and provides training on best practices for security and survivability engineering and management, including awareness of network traffic and malicious content.

The CERT Program occupies an entire floor of the SEI building and space in a nearby office building, and in 2005 will move to Carnegie Mellon's Collaborative Innovation Center (CIC). The CIC will also house another university research program in computer security called CyLab, of which Pethia is co-director. CERT is also a partner with the U.S. Computer Emergency Readiness Team (US-CERT), which is part of the U.S. Department of Homeland Security.

A Vision for Process Improvement

The evolution of the SEI's process program followed a deliberate trajectory under the leadership of Watts S. Humphrey. Humphrey had come to the SEI after retiring from IBM, where his senior management responsibilities included managing all of IBM's software development work. He understood what could go wrong with software development projects at IBM and elsewhere. "It was clear that the industry was in pretty bad shape," he recalls. "IBM had made improvements, but a lot of organizations were not performing well. It was a serious drag on companies, the economy, and society in general." Humphrey came to the SEI to pursue what he calls his "outrageous commitment": to change the world by changing the way software is developed. Humphrey's early projects included advising the DoD that software acquisition organizations should evaluate bids for software-intensive systems by examining the software development processes of the bidders. He also wrote columns and articles, including one for *IEEE Spectrum* about the Strategic Defense Initiative (SDI), the space-based system proposed by the Reagan administration to defend the nation from ballistic missile attack.

Watts S. Humphrey came to the SEI to pursue what he calls his "outrageous commitment": to change the world by changing the way software is developed.

At the time, scientists said SDI was not feasible, primarily because it was impossible to create the software."I wrote an article saying that, as far as software was concerned, it was not impossible. At issue was how you would have to do it," says Humphrey. In a little over a page of text, Humphrey laid out a picture of organizations, teams, and individuals, all performing with the discipline needed to solve a huge software-development challenge and employing quality principles already articulated by W. Edwards Deming

1994

The technical report *An Introduction to Software Architecture,* by David Garlan and Mary Shaw, describes the design problems inherent in large systems and provides an introduction to the emerging field of software architecture. This soon becomes a major focus area for the SEI.

1995

The People Capability Maturity Model is published, describing best practices in human resources, knowledge management, and organizational development. Other specialized models are published for software acquisition, systems engineering, and integrated product development.

1996

Former Air Force Col. Steve Cross, of the Carnegie Mellon School of Computer Science and the Robotics Institute, is named SEI Director.

The SEI Team Software Process℠ (TSP℠) methodology is introduced. This methodology enables PSP-trained engineering groups to apply integrated team concepts to the development of software-intensive systems, yielding improved productivity, lower costs, and improved time to market.

1997

The Capability Maturity Model Integration (CMMI®) project is initiated by the DoD to establish a framework to accommodate current and future models and bring the CMM approach into line with international industry standards.

The SEI Architecture Tradeoff Analysis Method℠ (ATAM℠) framework is developed and used on the Army's Mortar Fire Control Systems to identify critical architectural risks. The ATAM is now used worldwide to evaluate software architectures.

and Joseph Juran. "Even then I had that picture in my head of where we should be trying to go," Humphrey recalls. "It was not a magical new direction. It's what had been done in other areas of science and engineering." Humphrey's first pass at what would become the Capability Maturity Model (CMM) for Software, published as an SEI technical report in 1987, included maturity levels and an evaluation system for rating organizations. "The Air Force used it to do ratings on a couple of bids. They started to get serious about it. Meanwhile, I'd go out and talk at conferences. Management groups got quite interested, and they wanted their companies to get evaluated. They could see how they could improve, focusing on the maturity framework."

As more organizations pursued CMM-based process improvement, Humphrey and other SEI researchers saw gaps between their vision for a high-maturity software organization and the way that individuals and teams actually did software-development work. This led to the SEI Personal Software Process℠ (PSP℠) methodology for individual software developers and later the Team Software Process℠ (TSP℠) methodology for software development teams.

Large Impact, Smaller Niches

Other projects may yet achieve the status of the Capability Maturity Models and the CERT Coordination Center. "I thought the architecture work was important," says Druffel, referring to a project that Len Bass took over in 1992 to support the development of flight simulators for the Air Force.

Bass recalls, "Every time they got a new airplane, they would build a new simulator. What we came up with is what, today, we would call an architectural style or pattern. It was adopted by the Air Force and used as the basis for the design of half a dozen simulators." Druffel adds, "People might debate whether the architecture was the best one for simulation, but the fact is that it was an architecture for simulation that was scalable and reusable. It took a lot of the risk out, and the Air Force appreciated that work."

The SEI was also a strong technical contributor to the High Level Architecture (HLA), a general-purpose architecture for simulation reuse and interoperability developed under the leadership of the Defense Modeling and Simulation Office. HLA was approved as an open standard through the Institute of Electrical and Electronic Engineers (IEEE) in September 2000.

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Over the past decade, the SEI's work in architecture and reuse has matured to include tested methods and practices to enable software acquirers and developers to exert greater control over key product qualities such as reliability, security, and modifiability, to understand the tradeoffs among those qualities, and to use software architectures as blueprints for software product lines that are assembled from reusable components.

The SEI's founders thought that the institute would foster spinoffs—small companies that would carry an idea into broad transition in the commercial marketplace. This had been a success at Lincoln Laboratory, an FFRDC associated with the Massachusetts Institute of Technology. Lincoln not only fostered successful small companies, but also a new FFRDC, the MITRE Corp., in 1958, to provide engineering and technical services for the DoD's first air defense system, the semi-automatic ground environment (SAGE).

The SEI has helped to spawn a robust business in software process improvement consulting. The SEI Partner Network, which comprises organizations and individuals that are selected, trained, and licensed by the SEI to deliver authentic SEI services, now includes about

1998

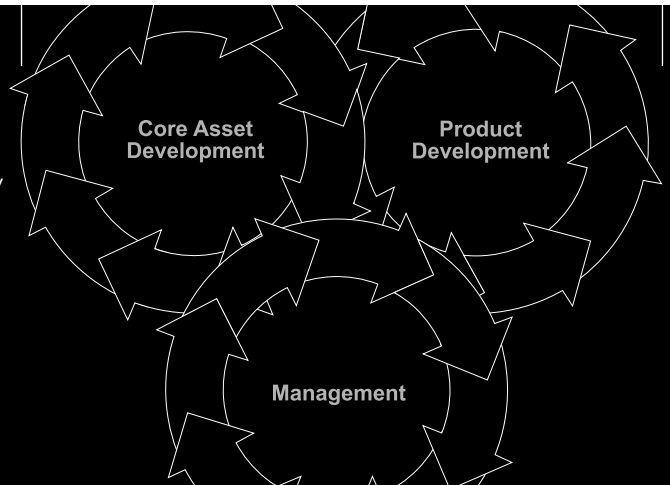
The Software Engineering Information Repository (SEIR) is created to provide a forum for exchanging information concerning software engineering improvement activities. Today the SEIR has more than 30,000 registered users and 21,000-plus Web pages (seir.sei.cmu.edu).

The first book on software architecture for practitioners, *Software Architecture in Practice*, is authored by SEI technical staff members and wins the prestigious JOLT award from *Software Development* magazine. This book is followed by three other SEI books on software architecture, which together have sold more than 40,000 copies.

The first SEI DoD Product Line Practice Workshop is held. This becomes an annual event that enables members of the DoD community to learn about the best commercial and government practices in software product lines and together reach solutions to problems that preclude product line success.

1999

The SEI *Framework for Software Product Line Practice*℠, a Web-based compendium of activities and practices necessary to succeed with software product lines, is published (www.sei.cmu.edu/productlines/framework.html).



250 organizations and 1,200 authorized individuals who teach courses in process improvement, network security, and software architecture, and conduct CMM and CMM Integration (CMMI) appraisals.

Rate monotonic analysis "has truly been transitioned into the field, and nobody cares where it came from. Really, it is an ideal case and an example… of what the SEI was set up to do."

The institute has also pursued transition in other ways. Largely as a result of SEI leadership, research, and publicly available resources, organizations throughout the world have formed some 150 computer security incident response teams (CSIRTs), which coordinate information and activities through the Forum of Incident Response and Security Teams (FIRST), which the SEI helped to found in 1990.

"Transition is almost like a black art," says Brandt. "Even very large enterprises have run into the challenge of how you make something that's good be broadly adopted. We've worked hard on transition, and we can demonstrate how pervasive our technologies are. Broad adoption of technology is the ultimate measure of success."

Rate monotonic analysis (RMA) is one such technology, says John Goodenough. "It's not as well known as CMM or CERT, but within the real-time community it's now called a classic way of analyzing systems." Real-time software is often embedded in life-critical systems such as avionics and other transportation systems, patient monitoring equipment, and process control systems in chemical processing and nuclear power plants. RMA helps software engineers understand and predict the timing behavior of real-time systems to a degree not previously possible. RMA was used to restart the Mars Pathfinder robot, the first NASA rover on the Mars surface, when it stalled in 1998 because of a software malfunction. "By and large people have forgotten that the SEI was involved," says Goodenough. "It has truly been transitioned into the field, and nobody cares where it came from. Really, it is an ideal case and an example, from my point of view, of what the SEI was set up to do."

A Framework for Transition

As the SEI's chief technical officer from 1996 to 2001, Goodenough helped steer other SEI technologies and methodologies through a repeatable transition process that includes case studies, gathering data, assembling interest groups, conducting conferences, and building up a group of users of the technology. This approach has been used for SEI-developed best practices in commercial off-the-shelf software systems, software product lines, and other areas, and is in the early stages for model-based engineering for real-time systems.

"When we started out, we were operating by the seat of our pants," Goodenough says. "Now we have a sound methodology for getting technology moved into practice, and we can advise others on how to do it as well. That's what attracted me to the SEI: the transition mission. It's very specialized work. We're not necessarily developing the technology but rather perfecting it, making it more practical."

Reorganizing and Expanding

Goodenough participated in a reorganization of the SEI in 1995 into its current structure of programs and initiatives that focus on software engineering process management, networked systems survivability, dynamic systems, and product line systems. "We were applying the lessons learned from our early years about what it would take for us to be effective," he says. The reorganization also established a single department, the Program Integration Directorate now headed by Brandt, to handle interaction with customers in the DoD, government, and industry. A fifth technical program, for acquisition support, was added in 2001.

2000

The SEI COTS Usage Risk Evaluation℠ (CURE℠) methodology is developed to help managers prepare to oversee commercial off-the-shelf (COTS)-based programs. CURE is a focused examination of the COTS-related aspects of a system development project.

With funding secured by U.S. Rep. Michael Doyle of Pennsylvania, the SEI establishes the Technology Insertion, Demonstration, and Evaluation (TIDE) Program. TIDE helps small defense and commercial manufacturers adopt state-of-the-art software technology to improve profitability and efficiency.

The Watts S. Humphrey Software Quality Institute is established in Chennai, India.

The first international conference on software product lines, Software Product Line Conference 1 (SPLC1), is organized and sponsored by the SEI and held in Denver, CO.

The SEI develops the SEI Product Line Technical Probe℠ (PLTP℠) methodology to determine the product line readiness of a major commercial organization. This diagnostic method has since been used to evaluate the product line practices of commercial and government organizations in a wide variety of domains.

2001

The SEI establishes the Acquisition Support Program to help the DoD and other government organizations improve their practices in acquiring software-intensive systems.

In 1996, the SEI again tapped Carnegie Mellon's computer science staff for personnel, this time for its next director. Steve Cross, a former U.S. Air Force colonel, was a principal research scientist with a faculty appointment in robotics and was head of the school's Information Technology Center.

"Whereas Larry Druffel was the visionary for building the foundation of the institute and looking at the technology, Steve Cross was much more focused on transition and looking for ways to expand the influence and impact the SEI was having in the U.S. and globally," says Clyde Chittister, who has been the SEI's chief operating officer since 1997.

Cross says that in the late 1990s, external events pushed the SEI "to really get real and more practical." For example, a cascade of worldwide network security problems, starting with the Melissa virus and the Y2K scare in 1999, led to a closer relationship between the CERT/CC and the U.S. Secret Service, and later the creation of US-CERT under the Department of Homeland Security. It also resulted in more collaboration among the SEI technical staff members who focused on network security and those in the areas of process and design. "We really began to emphasize the fact that vulnerabilities that resulted in buffer overflows and other problems were the result of poor design and development practices," Cross says.

Chittister says that other important accomplishments of Cross's tenure include CMMI, the establishment of the SEI-Europe℠ office, and growth in the number of licensed partners who teach and implement SEI methods and practices and provide approval services.

The CMMI project resulted from the success of the CMM for Software, which led to the use of the CMM's five-stage maturity-model architecture for other disciplines, including systems engineering and integrated product development. This expansion created challenges: organizations that wished to apply more than one model found that overlaps and conflicts in content and differences in architecture and guidance increased the cost and difficulty of organization-wide improvement.

After 1999, "we really began to emphasize the fact that vulnerabilities that resulted in buffer overflows and other problems were the result of poor design and development practices."

In 1997 the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics initiated the CMMI project in industry, government, and at the SEI, with the National Defense Industrial Association as a co-sponsor. Experts from a variety of backgrounds and organizations were asked to establish a framework that could accommodate current and future models and bring the CMM approach into line with international industry standards, particularly those from the International Organization for Standardization (ISO). A year later, the first CMMI model, which integrated software and systems engineering, was released.

"CMMI represents a maturing of how we approach systems and a recognition of the fact that software engineers and systems engineers are on the same side," Cross says. "You can't build any system without having software in it."

CMMI has been transitioned into widespread use relatively quickly. To date, more than 30,000 people have been trained in the CMMI methodology by the SEI and its partner network. In addition, new CMMI models have been developed that include supplier sourcing and integrated product and process development. There is also a companion module for acquisition organizations.

2002

The first International Conference on COTS-Based Software Systems (ICCBSS) is held. It is the first conference series to focus on the exchange of ideas about current best practices and promising research directions in creating and maintaining systems that incorporate COTS software products.

2003

The SEI responds to the rapid expansion of international software development with its first international office: SEI-Europe in Frankfurt, Germany.

The U.S. Department of Homeland Security partners with the CERT Coordination Center to establish US-CERT, a coordination point for prevention, protection, and response to cyber attacks across the Internet. This work includes the US-CERT National Cyber Alert System, which provides all citizens with timely, actionable information to better secure their computer systems.

The SEI launches its six-course software architecture curriculum and certificate programs for software practitioners and technical managers.

The SEI initiates work in predictable assembly from certifiable components to provide the necessary technology to ensure that component-based software engineering produces safe and reliable results in real-time, safety-critical areas.

US-CERT
UNITED STATES COMPUTER EMERGENCY READINESS TEAM

"CMMI represents a maturing of how we approach systems and a recognition of the fact that software engineers and systems engineers are on the same side."

Interest in Capability Maturity Models, CMMI, the Personal Software Process, and the Team Software Process has encouraged the SEI to sponsor an annual gathering of software professionals to learn about and share their experiences with software process improvement. The annual SEI Software Engineering Process Group (SEPG[SM]) conference attracts some 2,000 process improvement experts and practitioners and has inspired similar conferences in Europe, Latin America, and Australia.

Responding to Globalization

The SEI responded to the rapid expansion of international software development with its first international office in January 2003. SEI-Europe in Frankfurt, Germany, carries out the SEI's mission to help others improve the way they develop software by offering public courses, colloquia, workshops, industry memberships, and opportunities for joint research projects to software engineers in Europe. SEI-Europe also supports the many European automotive, telecommunications, and financial organizations that currently use or are adopting SEI methodologies.

"Software is becoming ubiquitous and there is a tremendous amount of outsourcing," Chittister says. "Software engineering is practiced throughout the world. The U.S. Department of Defense and other large organizations and corporations have to be concerned that all software, whether it's developed here or offshore, adheres to the same high quality standards. The SEI is working on the global transition of those standards."

Today, under Director Paul Nielsen, the Software Engineering Institute continues to pay dividends for its major sponsor, the Department of Defense, and for the field of software engineering. From 55 employees, the SEI has grown to 521, including 33 at its office near the Pentagon in Arlington, VA.

The DoD has given the SEI the freedom to pick its topic areas and then defend those choices. "In most cases, five to ten years later, we've developed a body of expertise that suddenly everybody wants."

"The SEI has been unusual in being able to pick topic areas in which people become interested five years later," says Goodenough. "Nobody else would have said that architecture or product lines were the things to focus on. But we were in the arena where the ferment was happening and progress was being made. The same goes for network security at a time when there really was no Internet. When we started our process and CMM work, there was certainly nothing there with any coherence. We made it important."

The DoD has given the SEI the freedom to pick its topic areas and then defend those choices, Goodenough says. "By and large we've been successful: in most cases, five to ten years later, we've developed a body of expertise that suddenly everybody wants. What could be a more significant track record than that?"

2004

Major General Paul D. Nielsen is named SEI Director. Nielsen previously commanded the Air Force Research Laboratory at Wright-Patterson Air Force Base.

The SEI forms the International Process Research Consortium, a team of recognized leaders in the field of process research, to explore the frontiers of process research and lay the groundwork for future process technologies. The IPRC currently consists of 17 research members and 8 sponsoring organizations.

Under SEI technical leadership, the Society for Automotive Engineers (SAE) publishes the Architecture Analysis and Design Language (AADL) standard for embedded real-time systems. AADL enables the development and predictable integration of highly evolvable systems, as well as analysis of existing systems.

The SEI holds the first Software Architecture Educators Workshop to educate college and university professors about software architecture practices and to foster the inclusion of these practices in undergraduate and graduate curricula.

2005

Watts S. Humphrey receives the National Medal of Technology for his contributions to the software engineering community. The National Medal of Technology is the highest honor awarded by the President of the United States to America's leading innovators.

▶ Defense programs for which the SEI has provided software engineering support include the Joint Strike Fighter Program, the DoD's focal point for defining affordable next-generation strike-aircraft weapon systems for the Navy, Air Force, Marines, and U.S. allies. The focus of the program is affordability—reducing the development cost, production cost, and cost of ownership of this family of aircraft.

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Dividing and Conquering Software Engineering Challenges

The SEI's Technical Program

The SEI program of work is conducted in three principal areas: software engineering management practices, software engineering technical practices, and software acquisition practices. Within these broad areas of work, the SEI defines specific initiatives aimed at solving problems that impede the ability of organizations to acquire, build, and evolve software-intensive systems predictably, on time, within expected cost, with expected functionality, and without vulnerabilities.

Management Practices

The ability to effectively manage the acquisition, development, and evolution of software-intensive systems is a critical requirement of SEI stakeholders. Success in this area increases the ability of software engineering organizations to predict and control quality, schedule, cost, cycle time, and productivity when acquiring, building, and enhancing software systems.

Engineering Practices

SEI work in this area aims to improve the ability of software engineers to analyze, predict, and control selected functional and non-functional properties of software systems. Work is primarily focused on defining, maturing, and accelerating the adoption of improved technical engineering knowledge, processes, and tools. The work is product oriented and focuses on the knowledge and practices that allow software engineers to predict and improve specific attributes of software systems.

Acquisition Practices

Acquiring software-intensive systems that work on their first promised date is a national imperative. The goal of the SEI program of work in acquisition support is to address the unique demands and challenges of acquisition by helping acquisition organizations to improve their processes and minimize risks.

▶ The SEI is working with the Army on acquisition of the Army future force, which includes the Stryker armored vehicle.

> "The SEI is in the trenches with key acquisition programs to help them define innovative acquisition strategies, identify and mitigate risk, and structure acquisition programs to reduce conflict and establish win-win relationships among all key stakeholders."

Brian Gallagher
Director,
Acquisition Support Program

Meeting the Challenges of Defense Acquisition

New requirements for integration and interoperability and the need to create systems of systems for net-centric warfare have increased the complexity of the software needed to achieve the DoD's mission. Acquisition program managers must grasp practical business concerns while also understanding risk management, systems engineering, integration of commercial off-the-shelf components, system architecture, interoperability, process capability, program management, safety and survivability, source selection, evolutionary acquisition, and contract monitoring. Those managers must also meet aggressive cost, schedule, and technical objectives.

Over the past two decades, the SEI has compiled a body of research and developed practical solutions in these areas. The SEI works directly with acquisition organizations in the Army, Navy, Air Force, non-service DoD, and civil agencies to help them apply these solutions to achieve their objectives.

CMMI Acquisition Module Released

One way to improve acquisition practices is to build systems right the first time by ensuring that the acquisition processes needed for a technically sound project are defined, implemented, measured, and maintained. To that end, the SEI and the Capability Maturity Model Integration (CMMI) Steering Group released the CMMI Acquisition Module (CMMI-AM), Version 1.0, for use by DoD and federal government acquisition offices.

The Acquisition Module is a condensed form of CMMI that defines effective and efficient acquisition practices, directed both internally toward the acquisition project and externally toward project monitoring and control of the selected supplier. These practices provide a basis for acquisition process discipline while balancing the need for agility: the module identifies practices that should be performed but does not prescribe specific implementation approaches.

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More than 50 DoD, Civil Projects Supported

The SEI supported acquisition efforts for more than 50 projects in FY 2004 with the Department of Defense and civil agencies. Among the projects were

- Future Combat Systems (Army), a family of manned and unmanned ground and air combat systems
- Transformational Communications Satellite (Air Force), a key component of net-centric warfighting capability
- DD(X) destroyer (Navy)
- Multi-Mission Maritime Aircraft (Navy) for anti-submarine and anti-surface warfare
- E-10A wide-area surveillance platform (Air Force)
- Joint Strike Fighter family of warplanes (multi-service)

Teaching and Researching Software Acquisition Skills

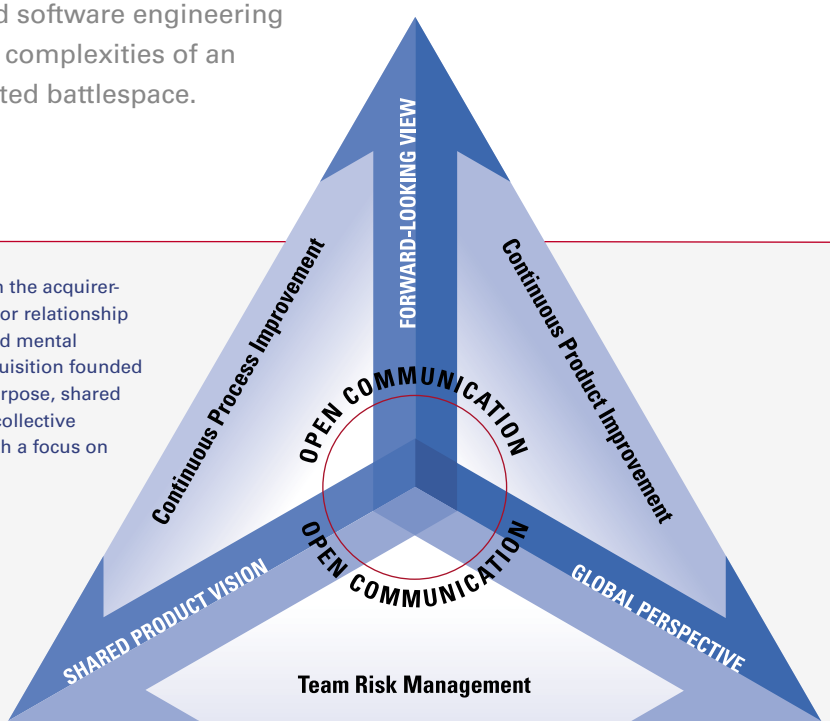
The SEI delivered its Software Acquisition Survival Skills course 10 times in FY 2004 to 139 attendees. This included three public offerings, six on-site offerings at U.S. Air Force locations, and one offering at a U.S. Army location. Nine instructors were trained to teach the course, so that the number of offerings can increase in FY 2005. The SEI also developed and piloted a new briefing, the Executive Process Overview.

The SEI published eight technical reports on risk-based diagnostics, the benefits of acquisition improvement, CMMI-AM, process for small manufacturers, measurements for software product lines, and system-of-systems interoperability.

SEI staff members wrote several articles on acquisition best practices for publications including *IEEE Software, Army AL&T,* and *CrossTalk* magazine. For a list of SEI publications on acquisition support, see www.sei.cmu.edu/programs/acquisition-support/publications.html.

"Providing enhanced capability to the warfighter is a complex and conflict-ridden endeavor. Operational forces demand war-winning systems today, and they need evolutionary enhancements to existing systems to maintain a cutting edge on the battlefield. Acquirers need to maintain cost, schedule, and technical baselines to uphold their duty as stewards of the taxpayers' money and satisfy oversight requirements. Contractors need to win contracts to stay in business and sustain the industry base. Underpinning these conflicts is an ever-increasing demand on systems and software engineering to solve the complexities of an interconnected battlespace. Today's problems, and certainly tomorrow's problems, can't be solved with yesterday's solutions. We need new and innovative teaming relationships among acquirers, developers, and operators to provide evolutionary, war-winning, cutting-edge capabilities to warfighters when they need them."

Brian Gallagher
Director,
Acquisition Support Program



SEI's Approach to Acquisition
The diagram represents the SEI's vision of the relationship among the acquirer, developer, and operator of software-intensive systems.

The core principle is open communication: information flows freely among all stakeholders, enabling formal, informal, and impromptu communication.

Three sustaining principles are

- team risk management, to continuously mitigate operational, development, and acquisition risks
- continuous process improvement, to mature the acquisition, development, and operational processes to meet the warfighter's objectives
- continuous product improvement, to enhance the warfighter's mission through delivery of improved capabilities on a regular, dependable schedule

The three defining principles are a forward-looking view, a global perspective, and a shared product vision.

All participants in the acquirer-developer-operator relationship share a vision and mental model of the acquisition founded on a common purpose, shared ownership, and collective commitment, with a focus on results.

The SEI studied the dependability problem of clock synchronization between satellites, such as this Boeing-built tracking and data relay satellite, and NASA ground stations.

Tricia Oberndorf
Director,
Dynamic Systems Program

> "The demands of both large systems of systems and small real-time embedded systems challenge our knowledge of how to engineer systems to certain qualities, especially performance, interoperability, and dependability. The SEI is creating the methods and models to meet these challenges."

Guiding Integration, Interoperability, and Dependability of Net-Centric Systems

Today's complex distributed systems require the integration of multiple systems into one interoperable system that can evolve while it continues to deliver optimal performance and dependability. This includes systems in which timing is critical and heavy load is the norm.

The SEI identifies, matures, and transitions software engineering methods and techniques that enable organizations to integrate components, systems, and systems of systems. The SEI focuses on leading indicators that predict interoperability success. It investigates the software implications of the net-centric operations vision and provides guidance on the selection and use of technologies and methods to field and sustain interoperable systems. It seeks solutions to organizational and programmatic interoperability problems, and it translates the DoD's net-centric warfare vision into everyday practice.

The SEI also matures and transitions technical practices for analyzing and predicting the performance and dependability of software systems. One major area of work is model-based real-time systems design and analysis. The goal is to establish a model-based engineering practice for embedded real-time systems development for avionics, aerospace, automotive, autonomous robotics, and similar systems applications. The SEI also conducts research into predictive tools and methods, such as structured rationales that show how evidence gathered during system design and testing supports claims of dependability and real-time performance, thus increasing confidence in the system.

Standard for Embedded Real-Time Systems Enables Analysis, Predictive Integration

Under SEI technical leadership, the Society for Automotive Engineers (SAE) Architecture Analysis and Design Language (AADL) standard for embedded real-time systems became an approved standard in September 2004. AADL enables the development and predictive modeling and engineering of highly evolvable systems, as well as analysis of existing systems. It supports early and repeated analyses of a system's architecture with respect to performance-critical properties through an extendable notation, a tool framework, and precisely defined semantics. SEI contributions include leadership of the small core standard editorial team. The SEI has developed tutorials on SAE AADL, which have been given in several venues, and more presentations are scheduled.

The SEI has also developed an initial prototype AADL toolset that includes a parser, a persistent XML representation of AADL models as a tool interchange representation, and a syntax-sensitive text editor based on Eclipse technology. These will be made available on an open-source extensible basis as a low-entry-cost AADL engineering environment.

Workshops, Reports Lay Groundwork for Interoperability Research

In FY 2004, the SEI conducted four workshops with stakeholders from the DoD and other government agencies to identify primary interoperability issues and to provide input on emerging focus areas.

The SEI provided technical leadership for the SAE Architecture Analysis and Design Language (AADL) standard for embedded real-time systems.

Several technical reports began to lay important foundations, including a report that identified the basic issues, programs, and research trends in interoperability; a report that analyzed current technological issues and gaps in research and provided the foundation for a research program and set of experiments in interoperability technologies; and a report that examines a customer problem in interoperability and reformulates a formal specification of the problem with implications for broader applicability to other potential applications. In addition, the SEI developed a data-collection instrument, conducted field studies, and issued a report on current practices in constructive interoperability.

NASA Work Includes Clock Synchronization, Mars Lander

The SEI continues to work with NASA on dependability cases. In 2004 SEI researchers studied the dependability problem of synchronizing the clock in a low-orbiting satellite with the clock in its ground control station at White Sands Test Facility in Las Cruces, NM. The SEI is also continuing to work with the NASA Jet Propulsion Laboratory in applying dependability-case technology on software to be used on the Mars Scientific Lander, scheduled for launch in 2009.

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"Large-scale, interactive, reconfigurable, net-centric systems will become more important in the future, but we don't know enough today about how to ensure the reliability and performance of such systems. The best approaches will require better methods of modeling, assembling, and reconfiguring systems so that they adapt quickly and well to new demand patterns. A model-driven approach to system development will become more common—that is, developers will define systems in terms of components and component interactions. Analysis tools then will be helpful in predicting and understanding the properties, such as reliability and performance, of these designs. Generation tools, guided by human developers, will allow the models to be faithfully realized in software. The focus on model-driven development will allow automatic and semi-automatic reconfiguration of systems as demand changes and as components fail."

John Goodenough
Senior Member, SEI Technical Staff
Team Leader, Performance-Critical Systems Initiative

"The future world cannot consist of large systems designed with full knowledge of everything that will be permanently around them. Different design approaches are needed. The emergent algorithm community has a sense of the emergent approach. I've been thinking about this with respect to data. You have huge pushes to a standard data model, which will never happen. So instead, let's do something radically different: create a data model in which the model is the emergent behavior. It emerges from the collection of data sources that are currently connected. That means that any system that wants to use that data has to live in the light of the data model that it's got today, which isn't the data model that it will have tomorrow. In fact, it's not the data model that it will have in five minutes' time. So we wind up with highly adaptive systems."

Patrick R. Place
Senior Member, SEI Technical Staff,
Dynamic Systems Program

The SEI is working with ABB Robotics to develop ways to safely extend plug-in code in application-specific ways.

Linda Northrop
Director,
Product Line Systems Program

> "Organizations are rapidly discovering a need to focus on the product—the structure of the software-intensive system, its capabilities, and its behavior. They need system behavior to be predictable by design, predictable by construction, and predictable across families of similar systems."

Achieving Business Goals Through Predictable Software Design and Construction

By using a product line approach to develop families of software-intensive systems, organizations can greatly reduce development cycles, improve return on software investments, and slash production costs. Using effective software architecture and component engineering practices, software acquirers and developers exert significantly greater control over key product qualities critical to business or mission success. Those key qualities such as reliability, modifiability, performance, safety, security, and affordability can be predictable before software testing.

The SEI conducts research and develops methods and technology that help organizations to

- efficiently produce successful software product lines that save both time and money
- develop software architectures that meet business goals and that serve as the blueprints for systems and the projects developing them
- predict the impact of software architectural decisions on product quality attributes such as performance and reliability, and later use that architecture to understand, maintain, and reuse parts of the system
- predict runtime behavior of component assemblies
- select software components on the basis of their certified component properties and predicted contribution to component assembly behavior

SPLC 2004 Largest Yet

The SEI's third Software Product Line Conference, SPLC 2004, held August 30–September 2 in Boston, was the largest international product line conference in the world to date, drawing more than 200 attendees. It offered 14 tutorials, six workshops, and seven product line technology demonstrations. The character of this SPLC was different from that of earlier ones: it changed from a conference for innovators or early adopters to one more geared to the early majority. This trend underscores the growing adoption of the software product line paradigm.

Plans were announced to join SPLC with its European counterpart, the Program Family Engineering conference, which will now be called SPLC-Europe, and expand the reach of the SPLC Steering Committee to include a third conference, SPLC-Asia-Pacific.

DoD Workshop Confirms Product Line Adoption

The Seventh Annual DoD Software Product Line workshop, held September 22 in Arlington, VA, brought together people from the DoD government and contractor community to share experiences, issues, and ideas for launching product lines in the DoD environment. As with SPLC 2004, this year's attendees made it clear that the product line approach is gaining momentum as more organizations are actually implementing software product lines in the DoD context rather than just thinking about it.

New Curriculum Equips Professionals to Adopt and Develop Product Lines

The SEI's new software product line curriculum was designed to equip software professionals with state-of-the-art practices so they can efficiently use software product lines to achieve strategic reuse business goals. The five courses, based on extensive SEI and community experience and on the SEI Addison-Wesley Series book *Software Product Lines, Practices and Patterns* by Paul Clements and Linda Northrop, provide an introduction to software product lines and practical guidance about how to adopt and develop them. The curriculum also covers both team and team-leader training for conducting the SEI Product Line Technical Probe℠ (PLTP℠) methodology. Software professionals can take these courses to earn certificates as a Software Product Line Professional, PLTP Team Member, or PLTP Leader.

SIMPLE Model Helps Estimate Product Line Costs, Benefits

The Structured Intuitive Model of Product Line Economics (SIMPLE) is a new, general model that supports the estimation of costs and benefits in a product line development organization. Software practitioners can use SIMPLE when deciding whether to use a product line strategy in a specific situation or whether to acquire or build certain core assets.

Product Line Adoption Factory Pattern Provides Strategic Roadmap

To help organizations overcome the formidable barriers to adopting product line practices, the SEI developed the Adoption Factory Pattern—a generic roadmap that lays out a manageable, phased product line adoption strategy.

Software Architecture Workshop for Educators Held

The SEI conducted a Software Architecture Workshop for Educators in August 2004. The workshop brought together 10 college professors to learn about software architecture, develop ideas about how to include software architecture in courses, and form the kernel of a community of software architecture educators. These professors are now teaching software architecture at their universities.

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"Organizations are becoming increasingly disillusioned over the inability of their software-intensive systems to meet expectations for non-functional qualities such as reliability, security, usability, performance, and flexibility. The creators of future systems must reckon with these challenges and will increasingly embrace the role of software architecture in determining predictable system behavior and forming the basis of families of systems that counteract the wanton over-population of unnecessarily unique systems. Software architecture will become self-reflective at development time and runtime. Systems will have the ability to 'reflect' based on predictions of behavior and will be able to take the appropriate action when either the predictions are not suitable or the predictions don't meet actual behavior. Systems will 'know' when they are 'qualified' for self adaptation or when they need to call for human help."

Linda Northrop
Director,
Product Line Systems Program

"Constraints lie at the heart of engineering discipline. An engineering problem may present unique challenges, but the skilled engineer knows how to coerce it into a form that can be solved with proven and well-defined techniques. Such techniques impose constraints on the form that solutions can take, but they also make it possible to predictably and routinely solve classes of problems. Today's software systems present engineering challenges that go well beyond functional correctness—the purview of programming—and include equally crucial non-functional qualities, such as security, performance, availability, fault tolerance, and so forth. A central challenge of software engineering research is to provide the proven and well-defined techniques for software engineers to routinely construct software systems that have predictable non-functional qualities. It follows that these techniques will impose constraints on how future software systems will be constructed."

Kurt Wallnau
Senior Member, SEI Technical Staff
Team Leader, Predictable Assembly from Certifiable Components (PACC) Initiative

SEI Curriculum Forms Basis of Army Software Architecture Initiative

The U.S. Army has made the SEI's software architecture curriculum the basis for a new Army Software Architecture Initiative. This initiative was launched to increase software architecture capability in the Army through widespread training in software architecture principles and methods and to institute software architecture evaluation in both the Army's policy and practice.

Pitney Bowes Uses SEI Quality Attribute Scenarios

The SEI's software architecture methods are now in use at Pitney Bowes, a leading provider of integrated mail and document management systems and services. At the recent Software Development Conference East, Nanette Brown of Pitney Bowes described how the company is using SEI methods to deal with quality-attribute scenarios and advocated the quality-attribute focus that the SEI has promulgated. She also described the success she has had with this approach, attributing her insights to the SEI.

SEI Helps ABB Robotics Safely Extend a Robot Controller

ABB Robotics, an industrial sponsor, has a need to supply industrial control systems to third-party integrators who will extend the controller in various application-specific ways. The "open" control system must still provide guaranteed behavior—in this case, real-time control over robot devices. The SEI developed a performance reasoning framework to address this increasingly common class of problem. The reasoning framework combines a design pattern based on sporadic servers with extensions to rate monotonic analysis that permit automatic prediction of latency for systems with periodic and aperiodic behavior. The ABB software system architect praised the SEI approach. "We have got a great theory…to make our system more robust…[and to] provide new solutions on the market and bring the robot control system closer to the open controller vision."

ComFoRT Reasoning Framework Verifies Component Behavior

Model checking is a proven way of verifying hardware behavior and is now being used on software. The SEI is pushing the technical frontier by applying this leading-edge verification approach to component specifications. ComFoRT is a reasoning framework designed by the SEI that specializes in temporal logic model checking to work with and exploit a component-based approach to software development. ComFoRT is used to automatically verify the critical runtime behavior of software components and their assemblies, such as security, reliability, and human-safety-related behaviors.

NCR

"NCR's partnership with the SEI to establish a product line framework within our APTRA software gives the ATM industry new levels of software integrity and quality. The patterns provide a revolutionary operational view and establish even greater efficiencies for our software development and significant benefits for our customers. The Product Line Technical Probe and the SEI's guidance are fundamental in establishing NCR's software product line adoption strategy. Ultimately, that means APTRA customers worldwide realize these benefits quicker."

Joe Gallagher
NCR General Manager, Global Software and Services Line of Business

▶Use of the SEI Team Software Process improved the performance of the Naval Air Systems Command (NAVAIR) team providing software support on the P-3C Orion, a multi-mission aircraft providing anti-submarine warfare and anti-surface warfare capabilities.

Bill Peterson
Director,
Software Engineering
Process Management Program

"We've addressed process improvement at all levels: organizations, teams and projects, and individual engineers. Closer integration of these efforts is now underway, and we are including more outside influences through the International Process Research Consortium, our involvement in international standards, and our performance measurement work."

Improving, Managing, and Measuring Software Processes Throughout Organizations

When organizations want to improve the way they do business, they often concentrate on securing the best people, methods, and tools. But it is processes that provide the means for coordinating those resources. Improving the performance of organizational processes has been shown to be an effective way to lower costs, improve productivity and quality, and deliver products and services on time.

Developed by team members from industry, government, and the SEI, the Capability Maturity Model® Integration (CMMI®) approach consists of models, appraisal methods, and training courses that have been proven to improve process performance. CMMI combines disciplines such as software and systems engineering and can work in concert with other process-improvement methods, such as ISO standards, Six Sigma, or the SEI Team Software Process℠ (TSP℠) methodology.

Using the TSP approach, software engineers build quality in rather than test defects out. TSP-trained development teams are disciplined, motivated, committed to quality work, and supported by their management. TSP teams operate by a work ethic in which the quality of every member's work is a team interest, every team member gathers and uses quality data, and the team uses that data to control product quality and improve processes. TSP teams strive to prevent every defect before test entry. TSP teams in organizations such as Microsoft, Intuit, the Naval Air Systems Command (NAVAIR), and ABB are nearing and in some cases achieving production of zero-defect software.

SEI work in measurement and analysis helps organizations use data to inform decisions and provides guidance in developing measurement programs that are tied to business goals. SEI techniques help organizations track their efforts to improve software processes, lower costs, reduce defects, stay on schedule, and gather valuable return-on-investment information.

Measuring Interoperability

During FY 2004, the SEI conducted research in the challenging area of system-of-systems integration and interoperability and published a technical note, *Measuring Systems Interoperability: Challenges and Opportunities*. This work was cited extensively on the Web site for the DoD's Data & Analysis Center for Software (DACS) Gold Practices (see www.goldpractices.com /practices/ei/index.php).

In a related effort, the SEI conducted research and provided guidance to help the Office of the Secretary of Defense identify the costs and risks of developing integrated and interoperable systems of systems. This research used theories of organizational behavior and complex adaptive systems as a framework to gain insight into the dynamics of developing such systems.

Second NAVAIR Group Speeds Climb Up Maturity Levels with TSP

In 2003, NAVAIR's AV-8B Joint System Support Activity employed the TSP to make rapid improvements in its software processes, as measured by the CMM approach. Proving that the first time was not a fluke, a second NAVAIR organization, the P-3C Software Support Activity (SSA), advanced from CMM Maturity Level 1 to Level 4 in just two and a half years—at least 17% faster than when the TSP is not used with CMM.

The P-3C SSA found that TSP accelerates improvement in many CMM and CMMI practices that apply to project teams through Maturity Level 4. The benefits cited include

- better communication within the project team and between the team and senior management
- a more collaborative work environment
- a planning approach that includes all stakeholders
- better estimates, because the teams plan their own work and use historical data
- increased software engineering productivity
- improved fidelity to schedule
- improved ability to estimate costs

After two successful pilots, Intuit will expand the use of TSP. Said one TSP team member: "I liked a lot of things about the TSP: the power it gives us at getting better at estimating and planning and all the fun data it gives us to see how we can improve."

TSP Helps Intuit Meet Goals, Reduce Time in System Test

Last year, Intuit Inc., a developer of financial management and tax preparation software such as QuickBooks, Quicken, and TurboTax, evaluated the TSP. Within a year, two of the initial pilot projects were completed with excellent results. The first pilot project finished within one week of plan. This team also met its goal of reducing the number of defects found during system testing by nearly 50%. The second pilot project delivered such high-quality software to system test that the team reduced the time spent in system testing to just 9% of its overall development effort. This compares to typical software projects where as much as 50% of the overall development effort is in system test. By reducing the system test schedule, Intuit estimates that it had 40% more time to spend on feature development. Intuit plans to introduce TSP on several more projects this year.

Indicator Template Documents Success

The SEI's indicator template—a tool for documenting an organization's measurement and analysis processes—is helping more organizations to establish successful measurement programs. During FY 2004, organizations including EDS, Warner Robins Air Logistics Center, and Randolph Air Force Personnel Center used the indicator template. By following the indicator template for planning and execution of their measurement activities, organizations can fulfill many of the practices of the CMMI Measurement and Analysis process area. The SEI will release a Web-based version of the indicator template in FY 2005.

IPRC Holds First of Five Workshops

Twenty-one leaders from industry and academia attended the first workshop of the International Process Research Consortium (IPRC), Aug. 11-13, 2004, in Huntington Beach, CA. At this meeting, consortium members began to generate the process research concepts that will be evaluated, synthesized, and prioritized in five subsequent workshops. With the IPRC, the SEI has assembled a core team of recognized leaders in the field of process research to jointly explore the frontiers of process research and lay the groundwork for future process technologies. The IPRC currently consists of 17 research members and 8 sponsoring organizations.

Caroline Graettinger
IPRC Chair

"The IPRC provides a way of tapping into the experiences of people all over the world to form a vision of opportunities in the future. This is a new piece of what the SEI does for its community, both to bring people together to share their information and to also disseminate it back out to help keep the community thinking about all possible opportunities."

VISION 20/20

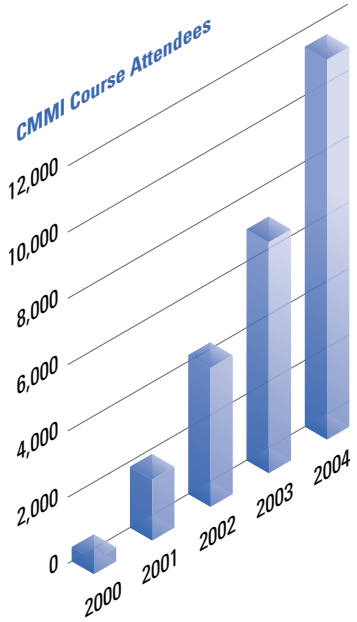
Combining CMMI, Six Sigma Accelerates Improvement

The SEI continues to research how process improvement techniques can be integrated for successful results. One recent project studied organizations that combined Six Sigma and CMMI techniques to accelerate the implementation of improvement practices and projects. Research shows

- Six Sigma has helped organizations move from CMMI Maturity Level 3 to 5 in nine months. For organizations that began their CMM-based efforts in 1992 or later, the median time to move from Maturity Level 3 to 5 is 38 months.
- Six Sigma can effectively be used at all CMMI maturity levels.
- Six Sigma can be used to drive decisions about CMMI representation, domain, and process area implementation order.
- CMMI organization-based knowledge enables Six Sigma project-based knowledge to be shared across software and systems organizations, enabling more effective institutionalization of Six Sigma.

CMMI Interest Increases

Interest in CMMI continued to grow in FY 2004 as attendance for the Introduction to CMMI course, taught by the SEI and its partners, jumped by 60 percent. Also, the average number of visits to the SEI CMMI Web site (www.sei.cmu.edu/cmmi) was 1,303,231 per month, up from 925,103 in FY 2003.



> "We're witnessing broad, continuing momentum toward putting software into products and systems we never envisioned before. From wireless to smart dust to all the various networks and technologies that are being built and developed, the thing that gives them the ability to transform and filter and process information and bring appropriate abstractions to decision makers is going to be software. We have a finite supply of people who can write code. That challenge will have to be addressed through combinations of improved processes and reasoning tools for software. The challenges are enormous, and I think we're really at the beginning. We have not, by any means, achieved a peak."

Mike Konrad
Senior Member, SEI Technical Staff,
Team Leader, CMMI Initiative

> "Process is just the beginning. The whole point of getting to CMMI Level 5 is getting organizations to a point where they can know more about their work than any one person could possibly know. Then they have the metrics, the skills, and the experience to actually improve and evolve and go in new directions at a very rapid pace. In 20 years, it's likely that almost everyone will be at Level 5. They're going to improve the state of the practice and the way that software engineering is done in ways that we can't possibly imagine. They're going to be able to do that because process provides the capability to really think and reason, objectively and rationally, about how the work is done."

Jim Over
Senior Member, SEI Technical Staff,
Team Leader, TSP Initiative

Companies Report CMMI Improvements

Major corporations are reporting significant improvements from adopting CMMI. For additional examples, see the CMMI Performance Results Web page at www.sei.cmu.edu/cmmi/results.html.

42% decrease in costs of rework at CMMI Maturity Level 3 (Raytheon)

85% reduction in schedule variance from development plan at CMMI Maturity Level 2 (NCR)

25% productivity improvement using CMMI over a three-year period (Siemens)

20% reduction in software costs by integrating engineering processes (Lockheed Martin)

SEIR Keeps Growing

The Software Engineering Information Repository (seir.sei.cmu.edu), an online resource for sharing information about software engineering practices and technologies, continues to grow. Statistics include

- 750,000-plus hits per month
- more than 30,000 registered users, representing 12,260 organizations in 107 countries
- more than 700 documents comprising 21,000-plus Web pages and over 400 links to other sites

▶ The SEI is developing methods to secure the information systems that underpin the world's critical infrastructures.

> "Late in 1988, when we started the CERT/CC, I don't believe any of us imagined the scope and magnitude of the security problem that we would face in the future. Today, it is obvious that 'bolt-on' security solutions are inadequate and that we must address security by building it in and paying attention to security issues across the entire system life cycle."

Rich Pethia
Director,
Networked Systems
Survivability Program

Protecting Networks, Detecting and Responding to Attacks

In recent years, computer networks have crept into almost every area of daily life. We rely on computers for storing vital information, providing emergency services, conducting business, and ensuring that critical infrastructures such as electricity and water services function properly. Organizations must ensure that their networked computer systems provide essential services in the presence of attacks and failures and that they recover full services in a timely manner.

The SEI provides practices and technologies that organizations need to protect against, detect, and respond to attacks on networked systems, especially those critical to U.S. infrastructure. In addition, SEI staff members analyze product vulnerabilities, perform research, publish technical documents, and present training courses. They also work to improve organizations' abilities to identify and prevent security flaws and to limit the damage caused by successful attacks.

A cornerstone of the SEI's work in network security and survivability is the CERT® Coordination Center (CERT/CC). Established in 1988 as the first computer security incident response team, the CERT/CC provides technical advice and coordinates responses to security compromises, identifies trends in intruder activity, analyzes vulnerabilities in products and systems connected to the Internet, works with vendors and other security experts to identify solutions to security problems, and disseminates information to the broad Internet community. To enhance their ability to identify solutions, CERT/CC experts analyze malicious code used by attackers. Staff members have responded to 320,000 security incidents that have affected hundreds of thousands of Internet sites, have worked on 16,000 reported vulnerabilities, and have issued hundreds of advisories and bulletins.

Providing Flexible Training for U.S. Army Reserve

The SEI designed an information assurance training program for the U.S. Army Reserve Information Operations Command (ARIOC). The program designed by SEI staff provides a multi-year framework for establishing and extending ARIOC mission readiness. Individual soldiers are given solid foundational training that provides them with information assurance knowledge and skills. Soldiers attend bootcamp-like introductory and advanced information assurance courses that instill technical depth and team-building skills through rigorous hands-on exercises. Individual units then get compliance assessment and remediation training through a scenario-based activity.

The command then undergoes organized incident response training, and the progression is capped by a two-level, hands-on certification exam proctored by the SEI. This curriculum provides in-depth technical information assurance training at every level of the organization.

U.S. Senator Rick Santorum (left) of Pennsylvania, shown with Carnegie Mellon President Jared Cohon, secured $1.5 million in funding for the SEI and U.S. Army Reserve partnership.

Malicious Code Database Available

The Artifact Analysis team of the CERT/CC has formed a community of interest surrounding an Artifact Catalog and is recognized as leading the research in this important area. The catalog is a database of malicious code, which includes viruses, worms, Trojan horses, and other programs used to attack computer systems, and associated analysis. The catalog enables analysts to reduce the amount of time required to identify threats from malicious code.

Enhancing Homeland Security
In 2003, the CERT/CC joined with the U.S. Department of Homeland Security (DHS) to create US-CERT, a coordination point for prevention, protection, and response to cyber attacks across the Internet. This work includes the US-CERT National Cyber Alert System, which provides all citizens—from computer security professionals to home computer users—with timely, actionable information to better secure their computer systems. The information is published on the US-CERT Web site (www.uscert.gov), which was established and is maintained by SEI staff.

"We know from our Internet experience that the more we get benefit from a technology, the more the 'bad guys' of the world will try to take advantage of it. We are all familiar with the problems of network worms and viruses. What would our everything-connected-to-everything world look like if those viruses found a way into our cars and medical devices? What new risks will we have when our hand-held communicators all become payment-generating devices and our pacemakers are subject to denial-of-service attacks? Computer and network hardware technology are already at the point that we have the CPU speeds, memory densities, storage densities, and network bandwidth and switching speeds to implement amazing new technologies. Now we must focus on a new science of system development with new methods, tools, standards, and verification and validation techniques, as well as the market mechanisms and government policies that encourage the production of ultra-reliable, ultra-secure, ultra-large systems."

Rich Pethia
Director,
Networked Systems Survivability Program

"In every way, we will have 'more' of everything. More threat, more attacks, more resources at risk, more interconnection, more communication, more emergencies. This is a simple projection from the growth trends from the past 20 years. Our main focus will shift from the Internet as our primary definition of cyberspace to the application domains that are shared with a majority of humans on the planet. No longer will we be defining the security of a desktop PC, but we will be defining the security of our latest purchase. We have already seen a shift away from operating-system security over the past 20 years in favor of Internet applications. This will continue until we do not even address the operating system. Control of the applications will be control of the system, regardless of the underlying platform."

Tom Longstaff
Manager,
Survivable Networked Technologies Project

Survey Finds Increase in Intrusions

The 2004 E-Crime Watch survey, conducted among security and law enforcement executives by *CSO* magazine in cooperation with the U.S. Secret Service and the SEI CERT Coordination Center, shows a significant number of organizations reporting an increase in electronic crimes (e-crimes) and network, system, or data intrusions. Among the findings:

43% of respondents report an increase in e-crimes and intrusions versus the previous year

70% report at least one e-crime or intrusion was committed against their organization

56% report operational losses

Team Studies Network Situational Awareness, Releases Tools

In response to a growing need to form a big-picture view of Internet threats, the SEI established the Network Situational Awareness (NetSA) group. NetSA staff members focus on research and engineering solutions necessary to quantitatively assess security posture, characterize threats, and give security analysts and network operators a better overall understanding of their networks.

In 2004, the team released an open-source version of the System for Internet-Level Knowledge (SiLK), a suite of tools to help operators and security analysts better understand their networks. Explicitly designed with large networks in mind, SiLK provides an efficient storage architecture to handle the massive amount of data associated with such data collection and analysis tools to rapidly query the large data set. For more about SiLK, see www.cert.org/analysis/silk.html.

Researching Insider Threats

Extensive analysis efforts by SEI staff led to the publication of the first report under the Insider Threat Study, conducted in partnership with the U.S. Secret Service's National Threat Assessment Center (NTAC). The first report, released in August 2004, focuses on insiders in the banking and finance sector who have intentionally exceeded or misused their authorized access to a network, system, or data and have affected the security of the organizations' data, systems, or daily operations. Reports on insider activity in the information technology and government sectors will be released in 2005.

Securing Critical Business Processes and Assets

The SEI established the Enterprise Security Management (ESM) project in 2004 to develop a systematic, managed, and measured process for securing the critical business processes and assets of medium to large organizations. The ESM team released the critical success factors technique in June 2004, which helps organizations align their security strategies with the organization's strategic drivers and guides, directs, and prioritizes their security activities.

Understanding Full Program Behavior

In the current state of practice, understanding the full functional behavior of programs is a difficult and time-consuming task carried out by reading and analyzing programs in human time scale. The problem is especially severe in analyzing the behavior of malicious code, where rapid understanding of functionality is critical for limiting compromises to systems and networks. The SEI is adapting function extraction (FX) technology to automate much of the analysis required to understand the security aspects of program behavior. FX is being applied to a desktop system for analyzing the behavior of malicious code, to enable fast and precise understanding of its functional effects as a necessary first step in creating mitigation strategies.

FloCon 2004 Workshop Held

The NetSA team held the FloCon 2004 Workshop in Washington, DC, to help build a community of analysts around network flow analysis. This workshop brought together analysts from across the federal civilian government, DoD, and international computer response teams to discuss analysis methods and to share best practices. Represented organizations included the DoD National Computer Security Center, the Department of Energy Pacific Northwest National Laboratory, the Swiss Federal Institute of Technology Zurich, the National Center for Supercomputing Applications, the U.S. Air Force, and the University of California San Diego Supercomputer Center.

Topics included

- flow collection architecture
- netflow data capture, processing, and operational analysis
- detection and analysis of scans on very large networks
- standardization efforts to support data exchange
- privacy impact and legal implications of sharing data

Roman Danyliw
Manager, NetSA

"Participation in the CERT NetSA FloCon Workshop comes from the entire continuum of the security community, from the battle-hardened operators to the cutting-edge researchers, who collectively define and advance the state of the art in network flow analysis."

SEI Director's Office

The SEI Director's Office ensures the smooth, efficient operation of the SEI. Director Paul Nielsen, right, and Chief Operating Officer Clyde Chittister build strong, collaborative relationships with leaders in government, industry, and academia, communicating the SEI's vision for software engineering.

SEI Management Team

The SEI management team leads the SEI by setting and executing SEI strategies, goals, and priorities and demonstrating the SEI core values of impact, excellence, and integrity.

Back Row from Left

Tricia Oberndorf
Director,
Dynamic Systems

Richard Pethia
Director,
Networked Systems Survivability

Brian Gallagher
Director,
Acquisition Support

Steve Huth
Manager,
Information Technology

Jill Diskin
Manager,
Human Resources

Peter Menniti
Manager,
Financial and Business Services

Front Row from Left

Linda Northrop
Director,
Product Line Systems

Tom Brandt
Director,
Program Integration

Sally Cunningham
Director,
Technology Transition Services

Bill Peterson
Director,
Software Engineering Process Management

Not Shown

Geir Fagerhus
Managing Director
SEI-Europe

Board of Visitors and Joint Advisory Council

Board of Visitors

The SEI's Board of Visitors advises the Carnegie Mellon University president and provost and the SEI director on the SEI's plans and operations. The board monitors SEI activities, provides reports to the president and provost on the state of the SEI, and makes recommendations for improvement.

Christine Davis
Chair, Board of Visitors

Consultant

Former Executive Vice President,
Raytheon Systems Company

Barry Boehm
TRW Professor of
Software Engineering,
University of Southern California

Director,
University of Southern California
Center for Software Engineering

William Bowes
Vice President,
Program Management,
Litton Industries

Thomas Brandt
Director,
Program Integration Directorate,
Software Engineering Institute

Gil Decker
Consultant

Former Executive
Vice President of Engineering
and Production,
Walt Disney Imagineering

Philip Dowd
Senior Vice President,
SunGard Data Systems

Trustee,
Carnegie Mellon University

Dave McCurdy
President,
Electronic Industries Alliance

Alan McLaughlin
Consultant

Michael Reiter
Professor of Electrical and
Computer Engineering and
Computer Science,
Carnegie Mellon University

Donald Stitzenberg
Vice President,
Global Supply Chain, Merial

Trustee,
Carnegie Mellon University

Joint Advisory Council

The Joint Advisory Council functions as the SEI's board of directors. It provides strategic advice to the SEI's executive agent and primary sponsor. This advice includes review of the SEI strategic plan and program plan.

Ronald Sega
Chair, Joint Advisory Council

Director, Defense Research & Engineering
Office of the Secretary of Defense,
Acquisition, Technology, and Logistics (OSD-ATL)

Blaise Durante
Deputy Assistant Secretary of
the Air Force for Acquisition
(Management Policy and
Program Integration)

Keith Englander
Chief, Information Management
Missile Defense Agency

Jim Engle
Deputy Assistant Secretary
of the Air Force for Science,
Technology and Engineering

Charles Holland
Deputy Under Secretary of
Defense (Science & Technology)

Nick Justice
Acting Assistant Deputy,
Systems Management and
Acquisition, Army

Thomas Killion
Acting Deputy Assistant
Secretary of the Army
(Research and Technology)

Rita Lewis
Deputy Assistant Secretary,
Networks and Information
Integration

Mike McGrath
Deputy Assistant Secretary
of the Navy for Research,
Development, Test and Evaluation

Bob Nemetz
Principal Deputy,
Acquisition Resources and
Analysis

Mark Schaeffer
Principal Deputy,
Defense Systems

Special Programs

SEI Partner Network

The SEI Partner Network helps the SEI disseminate software engineering best practices. Organizations and individuals in the SEI Partner Network are selected, trained, and licensed by the SEI to deliver authentic SEI services, which include courses, consulting methods, and management processes. The network expanded to 246 members in FY 2004, up from 188 in FY 2003. Partners provide services in process improvement, network security and survivability, and architecture.

Conferences

The SEI sponsors conferences, workshops, and user-group meetings. The largest of these, the Software Engineering Process Group (SEPG℠) conference, held in March 2004, drew 1,969 attendees, up 24 percent over 2003. Other events with SEI sponsorship drew 924 attendees. These events covered subjects including DoD acquisition of software-intensive systems, COTS-based systems, network security and survivability, software process research, software product lines, Capability Maturity Model Integration, and the SEI Team Software Process.

Education and Training

SEI courses help bring technologies and practices from the research lab into widespread use. In FY 2004, the SEI expanded its number of course offerings to 235, from 204 in FY 2003. The number of course attendees increased to 4,471 in FY 2004 versus 2,360 in FY 2003. Another 10,767 people were trained by SEI Partners using licensed course materials.

Membership Program

The SEI Membership Program provides leaders in the software engineering community the opportunity to learn, network, and advance through collaboration with the SEI and each other. In FY 2004, the SEI Membership Program had 1,784 members.

Affiliate Program

Through the SEI Affiliate Program, organizations place technical experts with the SEI for periods ranging from six months to four years. Currently, 28 affiliates are working on projects with the SEI to identify, develop, and demonstrate improved software engineering practices.

Geir Fagerhus
Managing Director
SEI-Europe

"The challenge, for all companies and organizations engineering software-determined products and services, is to deliver *quality software*—software that always works as specified and intended. The competitiveness of these organizations is directly related to their skills in developing quality software. SEI-Europe works to be the most effective integrator of technologies to ensure that software is the safest, most secure component of software-determined systems."

SEI-Europe

Software development is not limited to the borders of the United States or North America. Software development is a global activity with organizations adopting SEI products and services in Europe, Asia, Africa, Australia, and the Americas. In response to this globalization, the SEI opened its first international office in Europe in January 2003.

SEI-Europe in Frankfurt, Germany, carries out the SEI mission to help others improve their software engineering and management practices. SEI-Europe is financially supported by European industry leaders such as Robert Bosch and Siemens, with Dr. Thomas Wagner, Bosch executive vice president, serving as chairman of the SEI-Europe Board of Industry Advisors.

In FY04, SEI-Europe brought SEI expertise to Europe by delivering training to several hundred individuals in Capability Maturity Model Integration (CMMI), Standard CMMI Assessment Method for Process Improvement (SCAMPI), and Security Incident Response. SEI-Europe offers courses in its German headquarters as well as in training centers in Paris and London and provides on-site course delivery on request. The total number of individuals trained in Europe in FY04, including training provided by SEI Partners, exceeded 750.

SEI-Europe continues to form research partnerships with leading European organizations such as Bosch, Siemens, ABB, BAE Systems, and ETB to mature current technologies and add new products to the SEI portfolio. Already in its second full year of operation, SEI-Europe has undertaken significant activities in process improvement and projects in architecture analysis and security.

With employees from Germany, Switzerland, the Netherlands, the United Kingdom, Ireland, Poland, and Sweden, SEI-Europe already represents a cross section of the new Europe. SEI-Europe plans to add employees in and from as many European countries as possible to ensure that it represents the European industrial community.

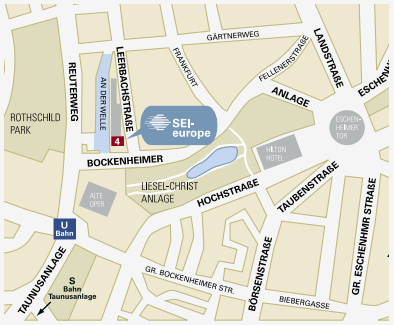
This strategy is furthered by actively seeking additional SEI Partners throughout Europe as well as establishing research collaborations with leading researchers. In FY04, SEI-Europe's main contribution in research collaborations was to add the leading European researchers in process improvement to the International Process Research Consortium (IPRC).

The SEI-Europe Team

VISION 20/20

"European users of SEI methodologies, models, and practices routinely deliver the right software, defect free, on time and within the budget, every time. Quality software—software that always works—is industry best practice. SEI-Europe is sponsored by European industry to establish a new level of best practice in the European marketplace. Building on current achievements of the SEI, we mature technologies and perform new research to fulfill the vision of quality software being the standard of leading European companies. The strategy to achieve this is to partner with industrial market leaders in application domains that are experiencing a transition to software-determined products and services. Currently these domains include the automotive industry, telecommunication, financial markets, the defense industry, and more. Based on successful research, we penetrate the market segments in Europe through development of SEI Partners who help to maximize the impact of our technologies. SEI-Europe also partners with the most prominent research organizations in Europe to maximize leverage with the European community."

Geir Fagerhus
Managing Director
SEI-Europe



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UK

SEI-Europe Training
Paris Location
Centre Regus
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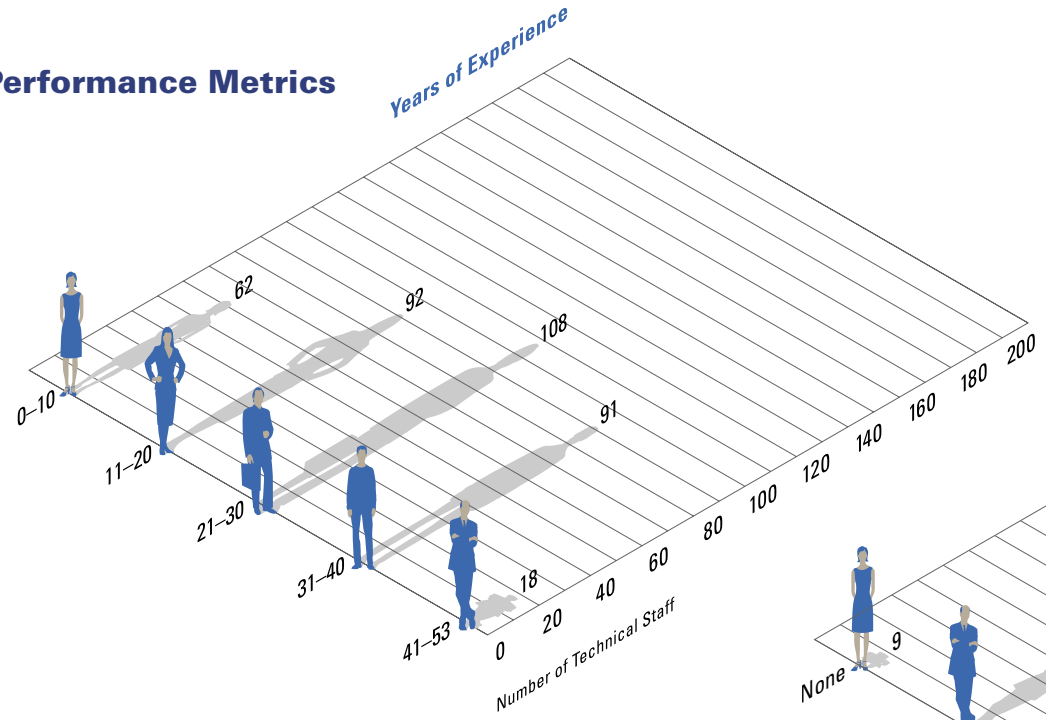
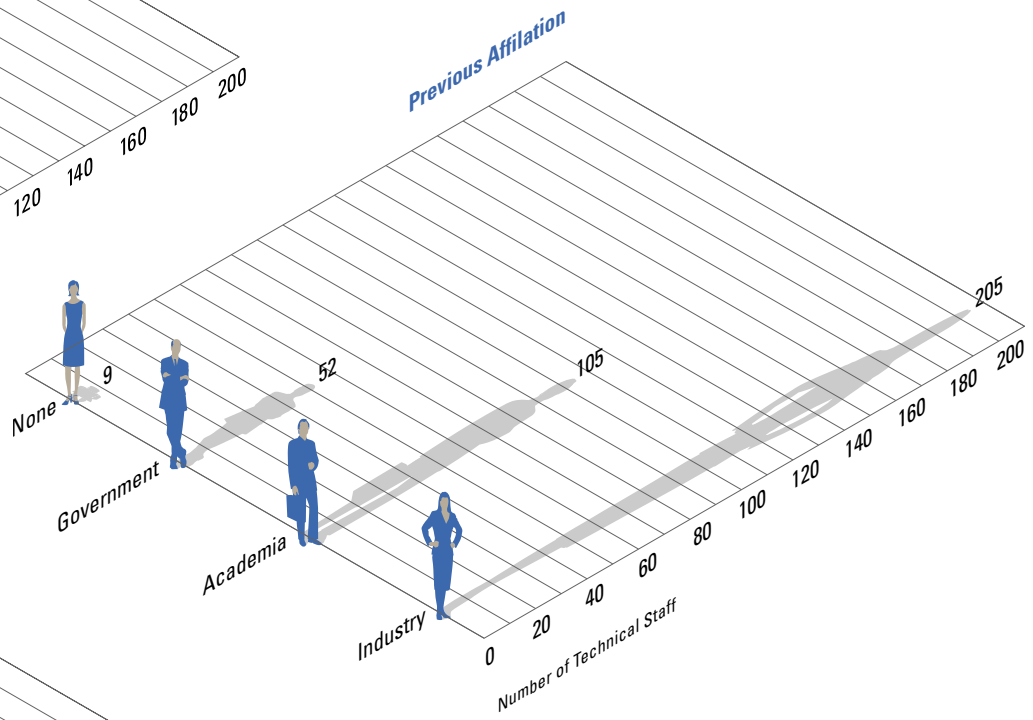
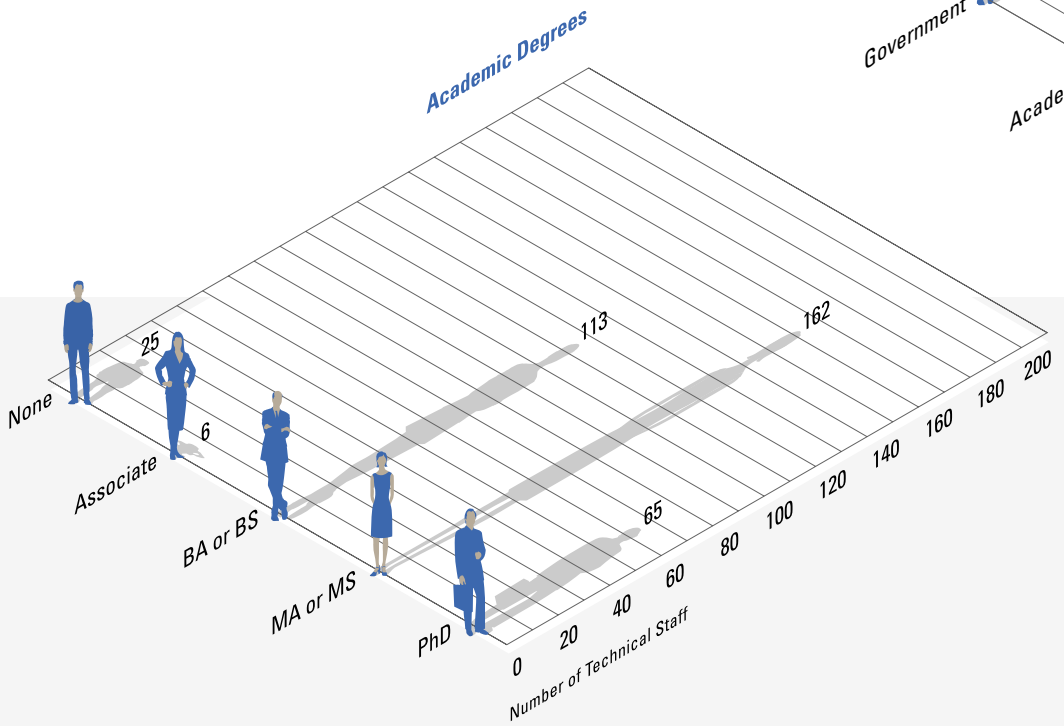
75116 Paris
France

Performance Metrics







SEI Staff

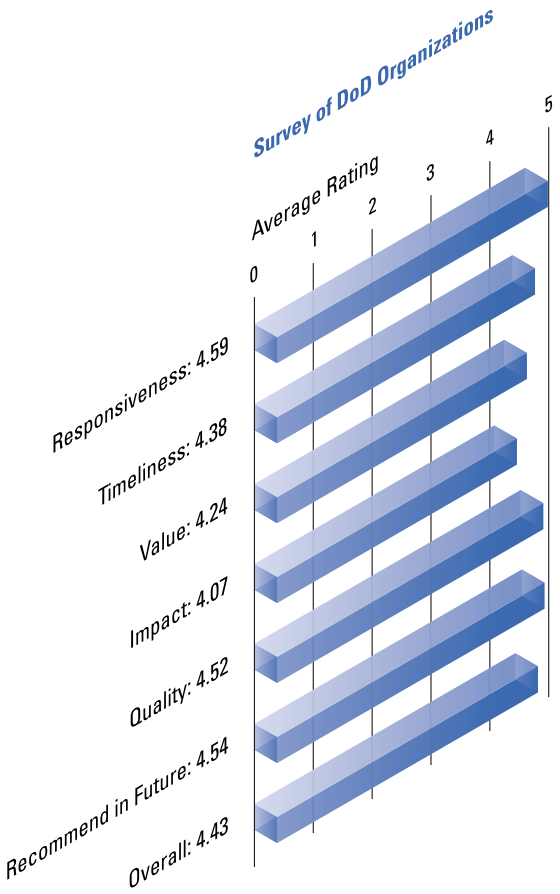
SEI staff members include technical staff, support staff, affiliates, and visiting scientists. SEI employment figures as of September 30, 2004:

371 Technical Staff

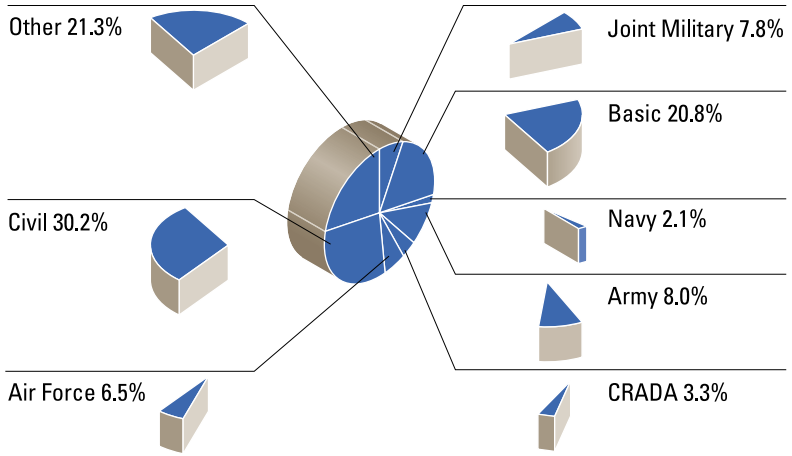
89 Visiting Scientists

138 Support Staff

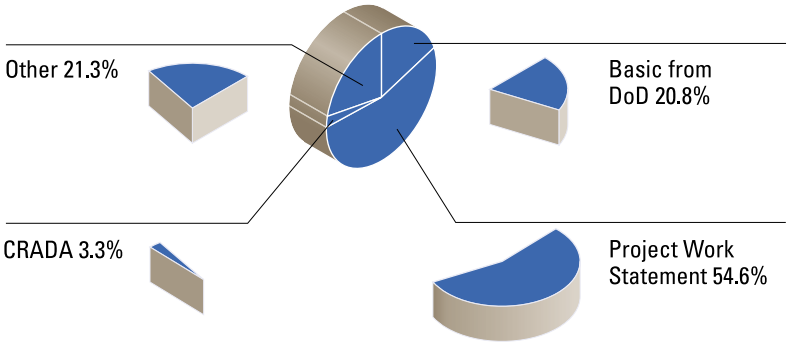
28 Affiliates



FY 2004 Funding by Organization



FY 2004 Funding by Type



Customer Survey

Each year, the SEI and the DoD Joint Program Office ask DoD organizations that have worked with the SEI to rate the institute's work in seven categories. This year 44 DoD and other government organizations were surveyed.

Using a grade of 4 as the equivalent of excellent, the SEI tallied the following results:

85%
of all customer responses were excellent or better

88%
of DoD customer responses were excellent or better

Funding for FY 2004 and Support for the SEI's DoD Sponsors

The SEI received $85.6 million in funding for FY 2004. The charts above show this funding arranged by funding organization and type of funding. A project work statement (PWS) is a task order from a specific government program to perform specific work.

A cooperative research and development agreement (CRADA) is an agreement with industry and academic collaborators. Basic funding is funding provided by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, the SEI's primary DoD sponsor, to execute the SEI technical program.

Other funds come from course and conference fees, and other recovered costs.

2004 Angel Jordan (AJ) Awards

The AJ Awards (named for Angel Jordan, distinguished Carnegie Mellon professor, dean, provost, and SEI founding father) are a tribute to the SEI core values of integrity, excellence, and impact embodied by SEI staff. The AJ Awards recognize those individuals and teams whose teamwork crosses organizational boundaries and whose outstanding commitment has had a significant impact on the SEI in one of the following categories:

Watts S. Humphrey
SEI Fellow

Director's Award for Excellence

Recipients of this award are individuals who foster interaction with the SEI and whose deeds and devotion to the SEI mission reflect the excellence of Angel Jordan.

Richard Pethia
Director,
Networked Systems Survivability Program

Contribution

Recipients of this award are staff members whose achievements resulted in a lasting positive change to the SEI or its constituents. They have made an exceptional difference to the SEI, Carnegie Mellon University, a specific customer, a collection of customers, or the software engineering community.

David Gregg
Operations Coordinator

Dedication

Recipients of this award consistently serve their internal and external customers through their personal commitment to a job well done, striving for excellence in everything they do.

Elaine Bolster, Amy Leyland, Carla Grandillo, and Rosemary Darr
Online Registration Team

Innovation

Recipients of this award have developed new approaches, methods, and systems that benefit the SEI or its constituents. They have demonstrated imagination and creativity in finding solutions to problems or fostering change.

2004 SEI Annual Report Online

The online version of the 2004 SEI Annual Report includes the information in this report and the following additional information for the fiscal year that ended September 30, 2004:

- SEI-sponsored conferences, including presentations and tutorials by SEI staff members
- SEI staff members who held technical leadership positions in software engineering
- a list of SEI-published documents and links to those documents, where available
- a list of book chapters written by SEI staff members
- a list of SEI contributions that are published in the proceedings of conferences
- a list of articles, not published by the SEI, that were written by SEI staff members
- a list of keynote presentations by SEI staff members
- a list of tutorials presented by SEI staff members
- press releases issued by the SEI
- government testimony delivered by SEI staff members
- a selection of media coverage of the SEI

www.sei.cmu.edu/annual_report

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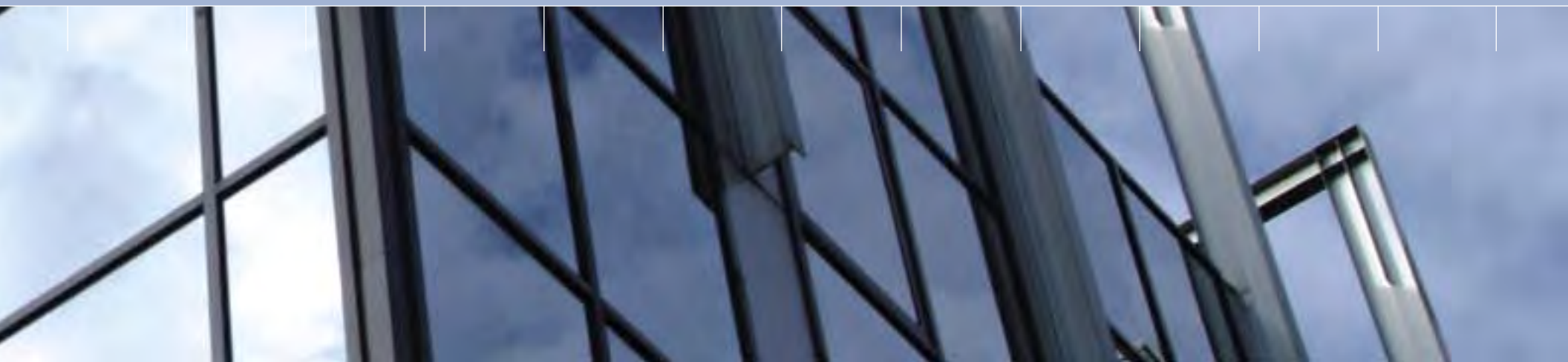
In Memoriam
Quinn Peyton, a member of the technical staff in the CERT Coordination Center (CERT/CC) and the Network Situational Awareness group at the SEI, died August 9, 2004. He was fulfilling his dream of piloting a plane across the United States.

Quinn's work focused on computing infrastructure with a slant on Windows NT/2000 environments. He also wrote software tools to support CERT/CC operations and helped to develop and maintain the AirCERT project. Before joining the SEI, Quinn was a systems analyst for the University of Pittsburgh.

Those who knew Quinn will miss his humor, his quiet sensitivity, and his zest for life.



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