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Information Assurance Test Facility (IATF), U.S. Army Electronic Proving Ground (EPG), Fort Huachuca, Arizona

TECHNICAL PAPER ABSTRACTS:

Reflections of an "Old Tester"

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This paper addresses some of the challenges facing the test and evaluation community. These challenges arise as equipment requirements become based more and more on the delivery of particular military capabilities as opposed to the historical approach of defining a set of performance requirements for individual pieces of equipment. A case in point is the U.S. Army's recent acquisition of the Stryker sets of equipment capable of executing, as a unit, particular military missions.

Lessons Learned: Testing Software Embedded in U.S. Department of Defense Weapon Systems

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Testing software embedded in U.S. Department of Defense (DoD) weapon systems is a complex and cost-driven task. Software components present a major development risk for DoD weapon systems because they escalate the cost and reduce reliability. This paper addresses the lessons learned in testing software systems based on real-world empirical experiences.

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An Integrated Approach to Software Flight Testing for U.S. Air Force Special Operations Forces Aircraft

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This paper describes the Integrated Product Team (IPT) approach used at the Warner Robins Air Logistics Center (WR-ALC) to support the flight testing of software for U.S. Air Force Special Operations Forces (SOF) aircraft. This approach builds on the strengths of the Software Engineering Division at WR-ALC, which include a world-class avionics integration support facility—the SOF Extendable Integration Support Environment (SOF EISE)—and the Software Engineering Institute's Capability Maturity Model Level 3 software processes. This IPT approach also draws upon the testing skills of Detachment 1, 46th Test Wing and the 18th Flight Test Squadron.

C3 Driver: Meeting the Software Testing Challenges of the Army Battle Command System (ABCS) and Beyond

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In January 2001, the Deputy Under Secretary of the Army for Operations Research, together with the Army's Military Deputy for Acquisition, Logistics and Technology, and the Army's Chief Information Officer, approved the implementation of a program to provide a standard Army Command, Control and Communications (C3) Driver for developers, testers and trainers. The U.S. Army Test and Evaluation Command, Alexandria, Virginia, executes executive-level management of the program in close collaboration with the Program Executive Office for Simulation, Training and Instrumentation, Orlando, Florida; Program Executive Office Command, Control and Communications-Tactical, Fort Monmouth, New Jersey; and U.S. Army Training and Doctrine Command Analysis Center, Fort Leavenworth, Kansas. The program successfully completed the first three phases in November 2001. This paper addresses the progress and challenges of the program in Phase II.

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Orion / EMEW: Software for Optimum Placement of Radio Frequency Test and Evaluation Assets

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The primary mission of the U.S. Army Electronic Proving Ground's (EPG's) Electromagnetic Environmental Test Facility is to assess the ability of Army systems and equipment, including threat forces, to operate compatibly in their intended electromagnetic environment, as well as to assess the influence of the operational electromagnetic environment on those Army systems and equipment. To help achieve this goal, EPG is developing a suite of integrated graphical user interface-based analytical tools, called the Orion Electromagnetic Command, Control, Communications, Computers and Intelligence (C^4I) Analysis Tool. The first application of Orion is the Electro-Magnetic Engineering Workbench (EMEW), which focuses on planning, analysis and evaluation of modern C^4I systems.

The Future of Testing and Evaluation: Approaching Autonomous Systems

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This paper enumerates the ways in which autonomous systems are expected to change the process of test and evaluation (T&E) of unmanned systems. Although the authors have an in-depth understanding of these systems, it must be noted that their experience with the military T&E process is more limited. This paper aims to provide experienced T&E professionals with thought-provoking issues that may stimulate additional attention to the challenges and opportunities presented by increasingly autonomous systems.

PRESIDENT'S CORNER

The past year has been challenging for everyone; it has been a year marked by concern and apprehension. We have watched events deteriorate in the Middle East, heard the repeated warnings of possible terrorist attacks, puzzled over the economy, worried about increasing health costs and, more recently, cringed at North Korea's announcement that it is restarting its nuclear fuels program. However, in spite of these global distractions, I can state with confidence that ITEA remained focused on its goals and objectives for the year, and the Association's progress has been impressive. ITEA Executive Director R. Alan Plishker recently provided me with some numbers for the year that not only tell a great statistical story, but also a story that emphasizes the hard work and dedication of ITEA's volunteer members.

■ ITEA's scholarship program has never been stronger. In the past year, the ITEA chapters, exclusive of supplemental funding from ITEA National Headquarters, presented 24 different institutions with $66,445 in scholarship funds for worthy students. Even better, these were grass-roots initiatives in that the majority of the students and institutions were located in the same geographical areas in which the chapters were located.

■ The 2002 Annual International Symposium instituted a best paper awards program. The program included a cash award for the top three papers, as well as recognition for the authors for their technical excellence in front of their peers at a formal awards ceremony. Some of these papers are being considered for publication in the *ITEA Journal*.

■ ITEA workshops and the Annual International Symposium achieved a new record in both attendance and revenue for the Association. Chapters conducted seven workshops that addressed important issues of the day for the test and evaluation (T&E) community. Under the leadership of Program Chair John F. Gehrig and Technical Chair Mark Smith, the Annual International Symposium set a number of records. The event was held in the popular city of Las Vegas, Nevada, and attracted 572 attendees, along with 52 exhibitors occupying 74 booth spaces.

■ The past year also saw new Association initiatives to form strategic alliances with other respected professional associations. ITEA was pleased to partner with the Directed Energy Professional Society to conduct a very successful workshop in Albuquerque, New Mexico. The San Diego Chapter also took advantage of an opportunity to support the 2002 International Data Link Symposium.

■ ITEA's short courses and tutorials program continued to grow and show impressive results for the year. ITEA sponsored or conducted nine short courses and 29 tutorials that were attended by more than 750 participants. The short courses and tutorials are foundational programs for the Association. They have remained successful by offering new course subjects and new locations to respond to the constantly changing needs of the T&E community.

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■ Chapter membership also has remained strong over the past year. The Association has seen an increase of more than 6 percent for chapter membership with 19 of the chapters showing positive growth. The total chapter membership in 2002 was 1,880, compared to 1,772 in 2001. Membership in 2003 is also on the rise (with more than 2,000 members at last count), and additional increases are anticipated throughout the rest of this year.

■ Corporate membership has also been a success story in the past year, with the total number of corporate members nearing 100 for the first time. This is an impressive achievement in light of the fact that corporate mergers and acquisitions have seriously cut into the list of current and prospective corporate members.

■ Chapter growth is also on the upswing. The French delegation has made good on its word and is in the process of setting up the Lafayette Chapter in France. ITEA also continues to work with existing and potential sites in the United States to build or rebuild robust chapters.

The "tale of the tape" indicates that ITEA had a great year. This is an impressive accomplishment, considering the many events that could have easily diverted us from our work. This is a record in which all members should take pride, and it speaks volumes of the hard work by ITEA volunteers who dedicated their time, energy and talent to make it happen. Let's continue working together as diligently in 2003, so that next year, I can again report to you a litany of impressive Association accomplishments.

Finally, I draw your attention to the 2003 Directory of Corporate Capabilities section in this edition of the *ITEA Journal*, showcasing our corporate members. Please visit this section and review the capabilities of ITEA's corporate members, as well as the outstanding contributions they make to the T&E community. ITEA corporate members not only contribute to the financial health of the Association, but they also contribute invaluable membership and leadership to our chapters, committees and Board of Directors. On behalf of ITEA, I welcome all of this year's corporate members, and the Association looks forward to a strong and continuing relationship with each of them in the future.

Gary Bridgewater

Software Can—*And Should*—Be Built Right the First Time

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Software is the engine of innovation in our Internet-connected world. Research yields new ideas that software transforms into new products. Unlike traditional industries such as the automotive and electronics industries, software requires no factories for manufacturing, no costly distribution system, and hence, no large infrastructure investment. But it does require the use of disciplined engineering practices by skilled software engineers.

Unfortunately, a gap continues to exist between the state of the art and the state of the practice of software engineering. A study commissioned by the Department of Commerce's National Institute of Standards and Technology (NIST) in May 2002[1] quantified the effect of software defects on the U.S. economy. The study, conducted by the Research Triangle Institute (RTI) in North Carolina, concluded that software defects cost the U.S. economy an estimated $59.5 billion annually, or about 0.6 percent of the gross domestic product. Because of the rapid growth of software complexity and usage, this number has steadily increased, and unless something is done to change current practices, it will almost certainly continue to do so.

These results confirm what we at the Software Engineering Institute (SEI)[2] at Carnegie Mellon University have been saying—and the work we have been pursuing—for years. As a federally funded research and development center dedicated to improving the practice of software engineering, the SEI conducts a body of work in technical and management practices that is focused on developing software the right way the first time, which results in higher quality, reduced rework, and predictable and improved schedule and cost.

Commercial software products are riddled with defects, commonly known as "bugs," that are introduced during the software's design and development. Defects in products that are accessible to the Internet render them vulnerable to cyber attacks. A recent example is the so-called "Slammer" worm that attacked the Internet in late January 2003. The worm exploited a known vulnerability in SQL Server 2000, a Microsoft database program. It hit tens of thousands of computers worldwide and slowed traffic on the network. Bank of America reported that its network was rendered inoperable by the worm, causing its automated teller machines (ATMs) to be unavailable to customers.


Dr. Stephen E. Cross

Bank of America was not alone. According to the Associated Press, other organizations that were affected included Countrywide Financial Corporation, a residential mortgage firm; American Express; and Continental Airlines. Major problems were also reported in South Korea and Japan, as well as in Finland, where the telephone system was affected.

"Peter G. Neumann, principal scientist at SRI International in Menlo Park, California, who has been in the thick of computer security discussions for nearly three decades, said that when it came to pointing out security risks, he often felt like King Canute, raising his fist in vain against the incoming tide," wrote Katie Hafner and John Biggs in the New York Times. "The increasing number of incidents and dependence on the Internet, and the number of patches one has to deal with for the known bugs, is amazing," Neumann said. "Things are getting worse rather than better."

The SEI's CERT[3] Coordination Center (CERT/CC) documented more than 4,000 commercial product vulnerabilities last year and determined that more than 95 percent of the 82,000 unique cyber incidents it investigated were a direct result of intruders exploiting such vulnerabilities. Yet the massive number of vulnerabilities seen in commercial software can be attributed to a modest number of root causes. These defects, and hence most cyber attacks, could be prevented if vendors used the proven best design techniques of software engineering.

Therefore, while I agree with the diagnosis of the NIST study, I disagree with the study's conclusion that higher software quality can best be achieved by significantly improved

software testing. In the SEI's view, the best way to ensure the quality of software is to design it in such a way that defects are not introduced into the software in the first place. Instead of futile efforts to test-in quality, we at the SEI believe that high-quality software can be produced only through high-quality engineering practices.

Practices for designing and implementing high-quality software already exist; at the SEI,experts have been identifying, developing and advocating such practices since the early 1980s. Commonly used software development practices—including an over-reliance on testing—result in lost productivity, as time and money are wasted on rework.The Standish Group in 1999 reported that 23 percent of software and information technology projects were cancelled before completion, while only 28 percent finished on time and budget with expected functionality.[4] Standish Group data also indicate that 60-80 percent of the cost of software development is rework—that is, fixing defects that are found during testing. While software must still be tested, testing and rework costs would be reduced if better design and implementation practices were used.

We in the software development community can reduce overall development and maintenance costs and improve quality by paying more attention to the early phases of the development lifecycle. For example, the SEI's Team Software Process (TSP)[5] (http://www.sei.cmu.edu/tsp) empowers teams to define and control their software practices within development projects. Using the TSP, self-directed teams make their own plans and commitments, gather data for tracking their work, and manage the quality of the products they produce.

Teams that use the TSP consistently produce high-quality software on predictable schedules. A few leading software organizations are now starting to introduce TSP. Early users have found that the TSP guides their software engineering teams in producing essentially defect-free software at lower costs and on shorter schedules than ever before.

The TSP has been used in a broad range of commercial, industrial and military software projects, with outstanding results. On average:

- Cost and schedule deviation from planned targets has been reduced to less than 10 percent;
- Delivered product quality has improved, with at least five times fewer defects;
- The times for system and acceptance testing have been reduced by five or more times; and
- Project productivity improvements have been measured at 50 percent or better compared to similar projects.

In one example, the SEI is helping ABB, one of the world's leaders in power and automation technologies, to improve its software quality. ABB's first TSP project team, the Galileo project, was launched in late August 2001. The 62-week project was delivered within 6.9 percent of the original schedule. The team used TSP planning and tracking techniques to meet the schedule.Equally impressive was the quality of the system that the Galileo team produced. During system testing, only .44 defects were found per thousand lines of source code. This represents a 10-times reduction in system-test defects compared to a previous project completed by ABB. The team relied on TSP quality management practices to achieve these results, removing defects early in reviews and team inspections. These practices saved time by reducing test effort to about 4 percent of the total project (see Figure 1).

In addition to providing training to software engineers and teams for producing high-quality software, the SEI is currently developing TSP for Secure Systems, based on proven TSP quality practices and the CERT/CC's extensive security skills and knowledge. The goal of this project is to develop a TSP-based method that can predictably produce more secure software. TSP for Secure Systems provides specialized training in secure design processes,implementation practices, review and inspection methods, test processes and security-related predictive measures. TSP for Secure Systems will be tested in several pilots.

ABB Project Summary Showing TSP Results Compared to Industry Standards

	ABB's First TSP Project	Industry Average
Schedule Variance	6.9%	222%[1]
Effort/Cost	23%	189%[2]
Originally specified features and functions in released product	>100%	61%[3]
Effort in system test	4.3%	N/A
Schedule in system test	12.9%	40%[4]
System test defect density	.44 def/KLOC	5 def/KLOC[4]

[1]Average schedule overrun. Reference: The Standish Group
[2]Average cost overrun. Reference: The Standish Group
[3]Percent of originally specified features and functions in released product. Reference: The Standish Group
[4]Reference: *Winning With Software: An Executive Strategy* by Watts Humphrey

Figure 1. The SEI's Team Software Process (TSP) results compared to industry standards

The TSP is based on the same quality principles that the Japanese introduced with automobile manufacturing in the 1970s. Toyota and others trained and motivated their entire workforce to focus on quality from the beginning of the development and manufacturing processes. Semiconductors, microelectronics and many other industries have followed this same strategy to produce better, less expensive and more competitive products.

Unfortunately, the software industry has not yet learned the fundamental quality lesson already learned by these other industries: that it takes longer and costs more money to produce poor-quality products than it does to do quality work in the first place. Results from the use of TSP on software development projects and the promise of TSP for Secure Systems suggest that achievement of the SEI's vision of defect-free software is within reach. Because we believe that endless testing and rework will never achieve this vision for the software engineering community, we at the SEI will continue to focus our efforts on improvement at the requirements, design and implementation stages of system development. o

Dr. Stephen E. Cross is the director and chief executive officer of the Software Engineering Institute (SEI), where he is responsible for oversight and management of all SEI activities. The SEI is a U.S. Department of Defense-sponsored Federally Funded Research and Development Center situated as a college-level unit at Carnegie Mellon University, Pittsburgh, Pennsylvania. Dr. Cross was appointed to this position on November 1, 1996. He also holds an appointment in Carnegie Mellon's School of Computer Science as a principal research scientist in the Robotics Institute. Dr. Cross is a member of the Air Force Scientific Advisory Board and is the past chairman of the Defense Advanced Research Projects Agency Information Science and Technology panel. He has published more than 50 papers on technology transition and the applications of advanced information processing technology. He received his Ph.D. from the University of Illinois, his master of science degree in electrical engineering from the Air Force Institute of Technology and his bachelor of science degree in electrical engineering from the University of Cincinnati. In addition, he is a graduate of the U.S. Air Force Test Pilot School (Flight Test Engineer program), the Air War College and the National Defense University. In 2002, Dr. Cross was selected as a Fellow of the Institute of Electrical and Electronic Engineers (IEEE) and as a Distinguished Alumnus of the University of Cincinnati College of Engineering.

Endnotes

1 Research Triangle Institute, "The Economic Impacts of Inadequate Infrastructure for Software Testing," report prepared for the National Institute of Standards and Technology, Program Office, Strategic Planning and Economic Analysis Group, May 2002, www.nist.gov/director/prog-ofc/report02-3.pdf

2 SEI is a service mark of Carnegie Mellon University.

3 CERT is registered in the U.S. Patent and Trademarks Office by Carnegie Mellon University.

4 Team Software Process and TSP are service marks of Carnegie Mellon University.

5 CHAOS Chronicles II, The Standish Group, 2001, www.standishgroup.com/reports/reports.php