Fusing the Future of Defense through Technology
Best Practices

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by Dr. Richard Turner

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Coming Events: We often list conferences, seminars, symposiums, etc. that are of interest to our readers. There is no fee for this service, but we must receive the information at least 90 days before registration. Send an announcement to the CROSSTALK Editorial Department.

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Call (801) 777-7026, e-mail: randy.schreifels@hill.af.mil

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The Software Technology Support Center was established at Ogden Air Logistics Center (AFMC) by Headquarters U.S. Air Force to help Air Force software organizations identify, evaluate, and adopt technologies to improve the quality of their software products, efficiency in producing them, and their ability to accurately predict the cost and schedule of their delivery.
What Are the Future Challenges of Software Technology?

As this issue of CrossTalk goes to print, the Software Technology Support Center (STSC) and Utah State University are busy working the final details of the 14th Annual Software Technology Conference 2002 – “Forging the Future of Defense Through Technology.” With abstract submittals up dramatically from the past year and a slate of distinguished keynote speakers, we are confident this year’s conference will be as strong as ever.

What is the future of software technology? As military departments transform operations, commands define new methods of force employment, and industry develops the next generation of advanced weapons, the prognosis of many software technocrats is unfolding – increased demand for quality, rising importance of information assurance, and new requirements demanding interoperability and exchange of data across systems. These technical challenges must be met while competing for talent, training a new workforce, and developing more mature organizations that can consistently deliver new products on schedule while increasing efficiency. The articles in this month’s CrossTalk explore some of these challenges.

First we present the results of a study by Dr. Richard Turner, faculty member of The George Washington University and assistant deputy director for the Software Intensive Systems Office of the Under Secretary of Defense. In A Study of Best Practice Adoption by Defense Acquisition Programs, Dr. Turner states that a survey of 14 software centers involving 150 programs indicated that despite demonstrated effectiveness and awareness, only about 25 percent of programs fully adopt any given best practice. He also explores barriers to implementation. The data show that with regard to software development and acquisition practices, leadership must focus on implementation.

How can organizations develop a culture and practices to achieve success? Dr. Barry Boehm, Dr. Daniel Port, and Apurva Jain of the University of Southern California and Dr. Victor Basili of the University of Maryland address this question in part four of a series of articles for CrossTalk. Building on the project-level benefits of Model-Based (system) Architecting and Software Engineering (MBASE), and Schedule as Independent Variable (SAIV) approaches in the previous article, this month’s work, Achieving CMMI Level 5 Improvements with MBASE and the CeBASE Method, describes how to address the CMMI organization-level process areas, particularly those of achieving continuous improvement.

The need for cooperation and data sharing among intelligence, military, and law enforcement organizations is the backdrop for U.S. Defense Department Requirements for Information Security by Kevin J. Fitzgerald of Oracle Corporation. Information security and multi-level security requirements are becoming primary considerations for the design of any major system (weapon or information). Fitzgerald outlines the basic requirements and information security terminology and makes a case for secure, independently evaluated solutions that incorporate security into the entire computing infrastructure.

Following this, Dr. Linda H. Rosenberg, Goddard Space Flight Center, NASA, in her article, What is Software Quality Assurance? defines the link between system safety and mission success to software quality assurance.

As the size of software products grows, effective test automation becomes necessary. In our next article, Surviving the Top 10 Challenges of Software Test Automation, Randall W. Rice discusses common problems with test automation and describes strategies for improvement. Making test automation an integral part of the organization and engineering process is necessary to gain its benefits.

Lastly, Information Security System Rating and Ranking by Dr. Rayford B. Vaughn Jr., Ambareen Siraj, and Dr. David A. Dampier all of Mississippi State University summarizes information gathered from a joint workshop conducted with both government and commercial sector engineers. The result was a characterization of information security metrics, and a case that processes, procedures, tools, and people all interact to produce assurance in systems. An effective set of measures must incorporate all these areas.

These topics – best practices, implementing organizational change, metrics, quality assurance, test automation, and information security – are but a few of those to be presented and displayed at this year’s Software Technology Conference, April 29-May 2, 2002. We hope to see you there as we all share ideas that will carry us into the future of software technology.

Lt. Col. Glenn A. Palmer
Director, Computer Resources Support Improvement Program

May 2002
The United States Department of Defense (DoD) spends an estimated $20 billion a year on software to support its infrastructure, operate its weapons systems, and provide command, control, communications, computing, intelligence, surveillance, and reconnaissance functions. DoD acquires the large majority of this software from contractor sources.

There have been significant cost overruns and schedule delays experienced in DoD software-intensive system acquisitions, resulting in numerous audits and evaluations of acquisition programs by independent government and industry organizations. Such evaluations have consistently indicated that programs are at risk partially because of failure to implement best practices. The evaluations have recommended the implementation of a variety of practices to improve performance [1-8].

A study by Anderson and Rebentisch [9] of 23 military programs found that best practice implementation for eight recommended commercial practices ranged from 17 percent to 83 percent with essentially half of the practices implemented under 40 percent of the time and half over 50 percent of the time.

This article presents the results of a study that measured best practice adoption in defense acquisitions.

**Study Methods**

The first critical issue was deciding whom to survey. It was desirable to obtain as wide a sample as possible with the least amount of interference in the acquisition program activities. For this reason, it was determined that the most effective way to access a wide variety of projects was to contact the various military software centers that provide software expertise to the programs. These centers act as intramilitary consultants or centers of excellence to provide expert resources to the acquisition program offices. Their personnel are in a position to provide informed judgments without any political bias from program loyalty.

The second critical decision was selecting the best practices for evaluating adoption. Since one of the objectives of this research was to determine how to support the implementation of best practices, it was decided to use the most widely known and oldest set of practices as the baseline for the adoption study. This would maximize the odds that program managers would have heard of the practices and that the acquisition personnel would have encountered them in use. Therefore, the original nine Airlie practices were used in the survey.

The following definitions of the Airlie practices are derived from the Software Program Managers Network (SPMN) materials [10, 11]. Copies of the SPMN material defining the practices were included in the materials sent to the survey participants. They are as follows:

1. **Formal Risk Management.** A formal risk management process requires acceptance of risk as a major consideration; commitment of program resources to managing risk; and use of planned, documented methods for identifying, monitoring, and managing risks.

2. **Agreement on Interfaces.** A baseline interface specification must be established and agreed to by all stakeholders before implementation activities begin. A separate software specification must be developed with explicit and complete interface information. This is particularly critical with human/machine interfaces and where system interoperability is a requirement.

3. **Formal Inspections.** Inspections of all acquisition and development documentation should be conducted according to planned, documented processes and the results placed under configuration control, tracked, and resolved.

4. **Metrics-Based Scheduling and Management.** Statistical quality control of costs and schedules should be maintained. Reasonable cost and schedule projections should be made before program start, and specific measurement processes should be put in place early in the program and rigorously followed. Measurement results should figure prominently in program reviews and management decisions.

5. **Binary Quality Gates at the Inch-Pebble Level.** Status should be tracked through binary completion of relatively small tasks. Activities are either incomplete or complete. This is to prevent the “80-percent-complete” syndrome where the estimated completion figure is reported without particular rigor.

6. **Program-Wide Visibility of Progress vs. Plan.** Core indicators of project health and performance should be readily available to all project participants. Anonymous feedback channels...
should be provided to enable bad news to be propagated up and down the project hierarchy without fear of reprisal for truth telling.

7. Defect Tracking Against Quality Targets. Defects should be tracked according to a planned, documented process; measured against established targets; and systematically tracked through removal or resolution.

8. Configuration Management. A planned, documented process is followed to identify, document, monitor, evaluate, control, and approve changes made during the system life cycle to any system-related artifact that is shared by more than one individual or organization.

9. People-Aware Management Accountability. Management should treat personnel as their principle resource by staffing qualified people, encouraging continuous improvement, and fostering an environment conducive to low voluntary personnel turnover.

Survey Instrument
In developing the instrument, we found it useful to think of adoption as having two components: awareness and implementation. Awareness, as defined by Hilburn [12], represents a level of individual knowledge about the practice that includes the following:

- Understanding of the existence and context of the practice within the context of software acquisition.
- A general, informal explanation of the practice.
- Identification of references (human/written) that provides greater depth of knowledge about the practice.

The other component, implementation, requires that the organization put into place the requisite infrastructure, training, resources, and policy to effectively utilize the practice in doing business.

The adoption survey instrument was designed to provide data that addressed both awareness and adoption. It collected data in the following areas:

1. The number of programs supported by the respondent to establish the overall program sample.
2. The size of those programs as designated by Acquisition Category (ACAT): ACAT I, ACAT II, ACAT III, or Other.
3. The quality of practice adoption for each program as measured by the compliance with the practice definition in the Airlie material. This was captured by having each participant

Table 1: Programs Reported by Service and ACAT Designation

<table>
<thead>
<tr>
<th>Service</th>
<th>ACAT I</th>
<th>ACAT II</th>
<th>ACAT III</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Force</td>
<td>1</td>
<td>0</td>
<td>16</td>
<td>62</td>
<td>79</td>
</tr>
<tr>
<td>Army</td>
<td>9</td>
<td>11</td>
<td>13</td>
<td>6</td>
<td>39</td>
</tr>
<tr>
<td>Navy</td>
<td>2</td>
<td>6</td>
<td>7</td>
<td>17</td>
<td>32</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
<td><strong>17</strong></td>
<td><strong>36</strong></td>
<td><strong>85</strong></td>
<td><strong>150</strong></td>
</tr>
</tbody>
</table>

Table 2: Percentage of Programs Represented by ACAT Designation

<table>
<thead>
<tr>
<th>ACAT I</th>
<th>ACAT II</th>
<th>ACAT III</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>8%</td>
<td>11%</td>
<td>24%</td>
<td>57%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 3: Percentage of Programs Represented by Service

<table>
<thead>
<tr>
<th>Service</th>
<th>ACAT I</th>
<th>ACAT II</th>
<th>ACAT III</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Force</td>
<td>53%</td>
<td>26%</td>
<td>21%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Overall Results of Adoption Study (Percent of Possible Program/Practice Pairs)

<table>
<thead>
<tr>
<th>Overall</th>
<th>ACAT I</th>
<th>ACAT II</th>
<th>ACAT III</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial</td>
<td>67%</td>
<td>52%</td>
<td>38%</td>
<td>69%</td>
<td>93%</td>
</tr>
<tr>
<td>Full</td>
<td>13%</td>
<td>29%</td>
<td>31%</td>
<td>24%</td>
<td>25%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>80%</strong></td>
<td><strong>80%</strong></td>
<td><strong>69%</strong></td>
<td><strong>93%</strong></td>
<td><strong>84%</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Air Force</th>
<th>ACAT I</th>
<th>ACAT II</th>
<th>ACAT III</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial</td>
<td>44%</td>
<td>None</td>
<td>56%</td>
<td>78%</td>
<td>73%</td>
</tr>
<tr>
<td>Full</td>
<td>56%</td>
<td>None</td>
<td>12%</td>
<td>21%</td>
<td>20%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>None</strong></td>
<td><strong>68%</strong></td>
<td><strong>99%</strong></td>
<td><strong>93%</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Army</th>
<th>ACAT I</th>
<th>ACAT II</th>
<th>ACAT III</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial</td>
<td>64%</td>
<td>45%</td>
<td>21%</td>
<td>13%</td>
<td>36%</td>
</tr>
<tr>
<td>Full</td>
<td>9%</td>
<td>24%</td>
<td>50%</td>
<td>67%</td>
<td>36%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>73%</strong></td>
<td><strong>70%</strong></td>
<td><strong>70%</strong></td>
<td><strong>80%</strong></td>
<td><strong>72%</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Navy</th>
<th>ACAT I</th>
<th>ACAT II</th>
<th>ACAT III</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial</td>
<td>89%</td>
<td>63%</td>
<td>29%</td>
<td>54%</td>
<td>52%</td>
</tr>
<tr>
<td>Full</td>
<td>11%</td>
<td>37%</td>
<td>40%</td>
<td>18%</td>
<td>26%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td><strong>68%</strong></td>
<td><strong>72%</strong></td>
<td><strong>78%</strong></td>
</tr>
</tbody>
</table>

Note: Numbers may not sum due to rounding

Results
Of the 14 centers asked to participate, seven responded to the data call. Six of the seven provided the requested data:

1. Army TACOM TARDEC
2. Army CECOM
3. Navy NAVSEA
4. Navy NUWC
5. Navy NAVAIR
6. Air Force ESC

The seventh respondent, Air Force ASC, provided narrative comments only. The responses covered 150 software acquisition programs broken out as shown in Tables 1 through 3.

AIRLINE PRACTICE ADOPTION DATA
The responses to the survey resulted in 1,350 possible program-practice pairs (150 programs times nine practices) where a particular Airlie practice could be adopted by a particular program. Table 4 shows the summarized results of the survey when calculated against this full complement of program-practice pairs. The terms partial and full refer to whether the respondent indicated that the program partially or fully implemented the practice.

Table 5 presents the adoption data by practice. The percentages represent the
Table 5: Adoption Results by Practice

<table>
<thead>
<tr>
<th>Best Practice</th>
<th>Overall Effectiveness</th>
<th>HE</th>
<th>VE</th>
<th>ME</th>
<th>SE</th>
<th>NE</th>
<th>Effectiveness Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal risk management</td>
<td>68%</td>
<td>13%</td>
<td>29%</td>
<td>31%</td>
<td>2%</td>
<td>8%</td>
<td>2.75</td>
</tr>
<tr>
<td>Agreement on interfaces</td>
<td>85%</td>
<td>21%</td>
<td>42%</td>
<td>14%</td>
<td>0%</td>
<td>0%</td>
<td>3.04</td>
</tr>
<tr>
<td>Formal inspections</td>
<td>79%</td>
<td>12%</td>
<td>21%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>3.01</td>
</tr>
<tr>
<td>Metric-based scheduling and management</td>
<td>83%</td>
<td>12%</td>
<td>37%</td>
<td>36%</td>
<td>0%</td>
<td>0%</td>
<td>2.97</td>
</tr>
<tr>
<td>Binary quality gates at the inch-pebble level</td>
<td>84%</td>
<td>25%</td>
<td>37%</td>
<td>28%</td>
<td>14%</td>
<td>0%</td>
<td>2.87</td>
</tr>
<tr>
<td>Program-wide visibility of progress vs. plan</td>
<td>86%</td>
<td>17%</td>
<td>30%</td>
<td>28%</td>
<td>14%</td>
<td>0%</td>
<td>2.88</td>
</tr>
<tr>
<td>Defect tracking against quality targets</td>
<td>76%</td>
<td>27%</td>
<td>36%</td>
<td>14%</td>
<td>0%</td>
<td>0%</td>
<td>2.88</td>
</tr>
<tr>
<td>Configuration management</td>
<td>83%</td>
<td>21%</td>
<td>36%</td>
<td>14%</td>
<td>0%</td>
<td>0%</td>
<td>2.89</td>
</tr>
<tr>
<td>People-aware management accountability</td>
<td>87%</td>
<td>21%</td>
<td>36%</td>
<td>14%</td>
<td>0%</td>
<td>0%</td>
<td>2.89</td>
</tr>
</tbody>
</table>

Table 6: Effectiveness Results by Practice

Common barriers reported were as follows:
- Lack of Resources: In general, program offices lack sufficient software-educated staff to implement many of the practices. Some lack sufficient core staff and are too busy fighting everyday fires to even consider best practices.
- Inadequate Contracts: Some contracts do not allow the flexibility needed to implement practices that require developer support without costly time- and energy-consuming modifications.
- Data Accuracy, Availability, and Latency: Practices often depend on accurate, timely data that are simply not available to many DoD programs. The lack or unavailability of valid, useful historical data often stymies estimation practices.
- Management Awareness and Commitment: Several comments were made about managers who did not understand that there was a problem or who did not want to spend the resources on a practice that might actually add risk rather than reduce it. Management must be willing to expend resources and perhaps political capital to institute practices.
- Lack of Credible Evidence: Comments were received concerning the need to prove that the benefits of practices were worth the cost of practice implementation.

Analysis

The first observation is that the practices are widely recognized across the programs as indicated by the high percentage (84 percent) of either partial or full implementations. Any particular practice was implemented in some form for at least 69 percent of the projects reporting. Three of the practices were implemented in around 95 percent of the projects. However, when only considering full implementations, those figures drop dramatically to an average of 25 percent across all programs with the lowest rate for a specific practice adoption of 15 percent and the highest rate of 38 percent.

Across services, adoption rates were generally consistent. The Army had a generally higher percentage of full implementation. Figure 1 illustrates the relationships between the services.

The practices were evaluated as relatively effective, with the majority of responses falling in the moderately effective to very effective range. The practice considered least effective (binary quality gates) still had a mean score of 3.27, placing it in the moderately effective category.

If we look at the adoption and effectiveness data together, there is some correlation between the perceived effectiveness of a practice and its adoption. This seems logical, since in budget- and schedule-constrained programs, the practices with the highest effectiveness would seem more likely to be implemented.

Conclusions

As stated earlier, we have used partial compliance as a surrogate that implies awareness and full compliance to imply implementation. Therefore, the primary finding from the adoption research is that despite the widespread awareness of the best practices (the average of programs implementing practices was 65 percent, which as we
previously noted, is probably an under-
statement of true awareness), there is very 
ilittle actual implementation (average 25 
percent). If we assume that the practice 
must be fully implemented to gain substan-
tial benefit, little value is being realized. 

In general, full implementation is not 
required; however, when coupled with the 
environment of defense acquisition, full 
(and possibly formal) implementation is the 
only way that a practice can expect to main-
tain focus and resources long enough to 
achieve benefits. This is particularly true of 
practices that have longer benefit latency. 

Judging by the effectiveness ratings, the 
Airlie practices have stood the test of time 
and represent valid best practices. Within 
the Airlie practices, configuration manage-
ment, agreement on interfaces, and risk 
management are essentially fundamental 
project management activities. 

As one respondent pointed out, “A 
number of the things promoted by the 
SPMN are simply established good prac-
tices that were known and practiced before 
the Airlie group documented them as best 
practices.” That said, there are still many 
programs that do not implement these 
practices effectively and so should be 
reminded of their importance. 

The research as conducted describes an 
environment where managers are aware of 
the benefits of acquisition practices, but 
they do not implement them. Either the 
barriers that prevent full implementation 
are sufficiently high to deter action, or the 
program managers simply choose not to 
implement the practices. The research sup-
ported both of these possibilities. 

To reap the benefits of the Airlie prac-
tices, or any best practices or other acqui-
sion technology, the software-intensive sys-

tem acquisition environment needs to be 
changed. The Software Intensive Systems 
(SIS) office within the Acquisition 
Resources and Analysis Directorate of the 
Under Secretary of Defense for 
Acquisition, Technology, and Logistics is 
working to improve policy, transition new 
acquisition technology into programs, 
coordinate independent expert program 
reviews, gather empirical data on best prac-
tices, and support broader software-related 
education across the acquisition workforce. 

SIS has completed additional research in 
the area of best practices in the last year: 
I will be writing another article that will 
describe the consolidation of more than 
100 published practices into 32 candidate 
practices. Those practices were evaluated 
for effectiveness by a panel of experts, and 
an analysis of their impact on software-

tensive, system-acquisition risk areas was 
performed. Further research on better ways 

of describing practices in a way more suit-
able to selection and evaluation by acquisi-
tion personnel is in the final stages. The 
results will be briefed in the SIS track dur-
ing the 2002 Software Technology 
Conference. The best practice research will 
be combined with other SIS efforts, includ-
ing the TriService Assessment Initiative and the CeBASE Experience Factory 
pilots, to support better decision making 
and improved processes in software-inten-
sive system acquisitions across DoD. 

Further work on documenting and dissem-
inating best practices is being performed in 
collaboration with the Data and Analysis 
Center for Software in Rome, N.Y. 

Figure 1: Comparison of Service Adoption Rates 

Figure 1: Comparison of Service Adoption Rates 

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Figure 1: Comparison of Service Adoption Rates 

Figure 1: Comparison of Service Adoption Rates

References 

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**Notes**

1. The eight practices studied were past performance, best value, commercial warranties, government/contractor relationship, performance-based specifications, commercial specifications and standards, streamlined contract administration, and use of commercial off-the-shelf/non-developmental item components. The study also found considerable benefits with few drawbacks for using the practices.

2. The nine Airlie Practices were established in 1995 by a group of experts convened by the Navy’s Software Program Manager’s Network at the Airlie Center outside Warrenton, Va. (now historically referred to as “The Airlie Council”).

3. ACAT I is defined as an acquisition program that is not a highly sensitive classified program, and that is designated as a Major Defense Acquisition Program; or estimated to require an eventual total expenditure for research, development, test, and evaluation of more than $355 million in fiscal year (FY) 1996 constant dollars; or for procurement of more than $2.135 billion in FY 1996 constant dollars. ACAT II is defined as those acquisition programs that do not meet the criteria for an ACAT I program, but are estimated to require an eventual total expenditure for research, development, test, and evaluation of more than $135 million in FY 1996 constant dollars; or for procurement of more than $640 million in FY 1996 constant dollars; or if designated as major by the DoD component head. ACAT III is defined as those acquisition programs that do not meet the criteria for an ACAT I or ACAT II. Other is defined as any acquisitions not designated with an ACAT level.

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**About the Author**


1931 Jefferson Davis Highway
Ste. 104
Arlington, VA 22202
Phone: (703) 602-0851 ext. 124
E-mail: rich.turner@osd.mil

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We accept article submissions on all software-related topics at any time, along with Open Forum articles, letters to the editor, and BackTalk.
Each branch of service in the Department of Defense has major initiatives to pursue more advanced software-intensive systems concepts involving network-centric warfare with self-adaptive networks and cooperating human and autonomous agents. The ability to balance discipline and flexibility is critically important to developing such highly dependable software-intensive systems in an environment of rapid change. Risk-management orientation enables users of Capability Maturity Model® IntegrationSM (CMMI®) to apply risk considerations to determine how much discipline and how much flexibility is enough in a given situation. The risk-driven nature of the spiral model and MBASE enables them to achieve a similar balance of discipline and flexibility. When these project-level approaches are combined with the organization-level approaches in the Experience Factory, the result is the unified Center for Empirically Based Software Engineering (CeBASE) method described in this article.

In “Using the Spiral Model and MBASE to Generate New Acquisition Process Models: SAIV, CAIV and SCQAI [3],” we showed how programs could use MBASE risk management techniques to avoid many overruns of fixed schedules and budgets. This is done by prioritizing desired features and inverting the development process to deliver the most important features within the available schedule or budget.

**MBASE and the CeBASE Method**

However, the spiral, MBASE, and Schedule as Independent Variable (SAIV) approaches all operate at the individual project level. This still leaves open the coverage of the counterpart CMMI organization-level process areas, particularly those of achieving continuous improvement of the organization’s processes.

In this article, we show how MBASE has been integrated with the University of Maryland’s (UMD) organization-level Quality Improvement Paradigm (QIP), Experience Factory (EF), and Goal-Question-Metric (GQM) approaches into a Center for Empirically Based Software Engineering (CeBASE) method, which successfully addresses these challenges. CeBASE is sponsored by the National Science Foundation, NASA, and the DoD, and jointly led by the UMD and the University of Southern California (USC).

As we explored the details of Maryland’s QIP, EF, and GQM approaches and USC’s MBASE approach, we found that they were expressing very similar principles and practices. The Spiral Model’s initial focus on system objectives was consistent with the QIP’s initial focus on organizational and project-specific goals expressed in...
context using the GQM approach. The EF’s focus on organizational learning to understand a system’s operational stakeholders and their goals corresponds strongly with MBASE’s stakeholder win-win approach to mutual stakeholder understanding and development of a shared system vision.

In the next section of this article, we summarize the key principles and practices of the QIP, the EF, and the GQM approaches; provide evidence of their successful application over 25 years of practice in the NASA Goddard-University of Maryland-Computer Science Corp. (CSC) Software Engineering Laboratory (SEL); and provide an example of their application at a systems as well as software level. In the section “The CeBASE method and CMMI,” we present the CeBASE method and show how its process elements cover the process areas of the CMMI. In “Using the CeBASE Method,” we show a version of the CeBASE method that has been successfully applied to more than 100 electronic services applications over six years’ practice at USC.

Our conclusions include a diagram summarizing the process model distinctions among traditional approaches such as the Waterfall Model and Software Capability Maturity Model (SW-CMM); project-oriented approaches such as the spiral model, MBASE, and the Rational Unified Process (RUP); and integrated project/organization approaches such as the CMMI and CeBASE Method.

**The QIP, GQM, and EF Approach**

**Framework and Methods**

Since 1976, the UMD has been collaborating with NASA-Goddard and CSC on the SEL. The UMD and the SEL have developed and refined a series of closed-loop feedback processes that have resulted in significant improvements in software quality across more than 100 large software applications in the last 25 years.

The formulation of these feedback processes is called the QIP [4]. It uses six steps to provide an organized approach to continuous software quality improvement: 1) characterizing the organization, 2) setting goals, 3) choosing and instrumenting an appropriate process, 4) executing and monitoring the process, 5) analyzing the data to identify improvements, and 6) packaging the experience and improvements for future use.

The QIP makes use of the GQM approach, which is a mechanism for defining and evaluating a set of operational goals using measurement [5]. It ensures that your general goals are elaborated into specific questions and metrics for tracking progress and evaluating success, and that your people do not waste effort collecting and analyzing data weakly related to your goals.

The GQM approach can be applied at both the project level and the organization level. The EF [6] provides a consistent way of operating at both levels, as shown in Figure 1. Organization and project goals are determined by involving the relevant success-critical stakeholders in negotiating mutually satisfactory (win-win) and achievable goals.

For example, the organization may set a goal to reduce its projects’ software cycle time by 50 percent. The initial implementing project may set goals and plans to have each project activity reduce its calendar time by 50 percent. As the project proceeds, its progress is monitored for progress/plan/goal mismatches, as shown at the bottom of Figure 1. While design, code, and test planning may finish in 50 percent less time, integration and test may start showing a 50 percent increase rather than decrease in duration. Analyzing this progress/plan/goal mismatch would determine the root cause to be delays due to inadequate test planning and preparation of test tools, test drivers, and test data. Further, shortening the test plan activity had produced no cycle time saving, as test planning was not on the project’s critical path.

The results of this analysis would be fed into the organization’s experience base: Future cycle-time reduction strategies should focus on reducing the duration of critical path activities, and options for doing this include increasing the thoroughness and duration of noncritical-path activities. Overall, as shown in the center of Figure 1, the EF analyzes and synthesizes such kinds of experience, acts as a repository for the experiences, and supplies relevant experience to the organization on demand. The EF packages experience by building informal and formal models and measures of various processes, products, and other forms of knowledge via people, documents, and automated support.

**QIP, GQM, and EF in Practice**

The application of the integrated set of these methods is referred to as the Experience Factory Organization, which resulted in a continuous improvement in software quality and cost reduction during the quarter-century life span of the SEL. When measured during three baseline periods in 1987, 1991, and 1995 (each representing about three years of development efforts), the demonstrated improvements included a 75 percent decrease in development defect rates from 1987 to 1991, and a 37 percent decrease from 1991 to 1995. We also observed a reduced development cost of 55 percent from 1987 to 1991 and of 42 percent from 1991 to 1995 [7, 8].

A more detailed example of improvement over time, in Figure 2, shows the defect rates in defects per thousand delivered lines of code (K-DLOC) for similar classes of projects at CSC during the application of the EF concepts. Over time, the defect models became well established and the range of variation (indicated by the upper and lower lines) narrowed, allowing managers to better manage quality [9]. Thus, the EF approach enabled the SEL portion of CSC to achieve SW-CMM Level 5 improvements well before CSC became a Level 5 organization in 1998. With the CMMI’s emphasis on measurement and analysis as early as Level 2, the opportunity is here for other organizations to use the EF approach to achieve CMMI Level 5 benefits well before reaching Level 4.
Various EF concepts have been successfully applied in other organizations, including Daimler Chrysler, Robert Bosch, TRW, and Allianz.

**Applying EF Concepts at the Systems Level**

**Systems-Level Goals and Questions**

Many software organizations interpret the EF concepts at just the software level. They miss many opportunities to reap much more significant returns on investment at the systems level. For example, suppose that your software intensive project has a proposed goal for an improvement initiative to reduce the project's software defect rates. What should be your next step? Usually it would be to look down from the software goal into the software details. How will we define defect? What are the counting rules for overlapping defects? What are our current defect rates?

With EF at the systems level, your next step is to look upward and sideways from the software and ask system-level questions. Why do we want to reduce software defect rates? What system goals are being frustrated by software defects? Where are the frustrations the greatest?

For example, in an operational order-processing system, the answers may be that the software defects are causing 1) too much downtime in the operation's critical path, 2) too many defects in the system's operational plans, and 3) too many new-release operational problems.

These insights enable you to reformulate your improvement initiative goal to decrease the organization's software defect-related losses in operational cost effectiveness. Items one through three become initial high-payoff target sub-goals for the initiative. Given this new goal and context, what should be your next step?

**Sub-Goal Level Questions, Models, and Metrics**

Again, a good next step is to ask why the software defects are causing operational problems, often with the help of models. For example, Figure 3 shows a critical-path model for analyzing the order-processing downtime and delays caused by software defects. Analyzing this model may lead to several valuable insights, improvement strategies, and system payoffs:

1. Often, major sources of delay are additional manual processing delays caused by software or non-software problems, as with the Scientific American order processing system discussed in Boehm [10].
2. The logic for packaging and delivery scheduling can become quite complex when only part of an order is in stock. (It is generally okay to send a partial shipment at Amazon.com, however, not for jet engine repair parts.) Software defects can again cause considerable operational delays.
3. "Produce status reports" defects should not be on the operational critical path. This module was probably put on the critical path by a programmer's detailed design coupling and cohesion decision without considering its potential system effect, resulting in status-report defects causing order-delivery delays.
4. The overall legacy order-processing system may just be too slow and difficult to modify and should be replaced downstream by a new Web-based order-processing system. It is generally good to be asking why not as well and why questions.

**Putting it All Together**

Each of these sub-goal-related initiatives needs to be monitored and controlled with respect to improvement-related metrics such as order-processing cycle time and user satisfaction. The results need to be integrated with other ongoing improvement initiatives to ensure synergy and integration with the overall organizational experience base discussed earlier in the "framework and methods" section. The sidebar on page 12 shows the resulting systems-level EF-GQM initiative steps.

These systems-level EF-GQM approaches are already being practiced by leading-edge software organizations. Two of the recent Institute of Electrical and Electronics Engineers' Software Process Achievement Award winners, Advanced Information Services, Inc. (AIS) and Tinker Air Force Base, are good examples [11, 12].

AIS uses Balanced Scorecard techniques to integrate its software, systems, project, and organizational goals in such areas as customer satisfaction, financial performance, employee growth, process improvement, and organizational learning capability. Specifically, AIS periodically assesses its performance and rate of progress in these areas on a Balanced Scorecard form and uses the results to adjust its improvement efforts in each area. Tinker has used its software insights to stimulate systems-level initiatives with its counterpart hardware and test organizations to improve system-level cycle time and to deliver quality in such areas as B-2 Test Program Sets.

This kind of approach is what transitioning from the software CMM to the CMMI is all about. It requires software organizations to be more pro-active than reactive in interacting with the operational system stakeholders. It gets software people applying their necessary expertise to system issues. It results in much larger bottom-line payoffs for the operational system stakeholders. The next two sections discuss how the CeBASE method integrates software and system-level activities as well as project- and organizational-level activities and how its practices map to the process areas and practices in the CMMI.
The CeBASE Method and the CMMI

The CeBASE Method Framework

Overall, we found that both EF-GQM and MBASE could be integrated into a common CeBASE method. Its framework is organized around a trio of common strategic themes, shown by the vertical pairs in Figure 4. These themes are the stakeholders’ shared vision for the organization or project; risk-driven plans for process, product, and people; and continuous monitoring and control. As seen in Figure 4, these themes express both the operation of EF-GQM at the organizational level and the operation of MBASE-GQM at the project level. Within a large diverse organization, we may wish to consider a particular set of projects within a portfolio or product line of related products or services.

To start at the upper left of Figure 4, the organization’s value propositions are often contained in an organizational mission statement. This will cover the organizational stakeholders’ agreed-upon win conditions and will be expressed in terms of such Balanced Scorecard elements as customer satisfaction, financial performance, employee growth, process improvement, and organizational learning capability.

Improvement goals and priorities will come from Balanced Scorecard assessments. These might include such goals as reducing software development cycle time or reducing average order-delivery time. The specific quantitative goals, e.g., reduce software development cycle time by 50 percent, would be based on initial cost/value analyses. These are developed using such techniques as the DMR Consulting Group’s Results Chains linking improvement initiatives to contributions and benefits-realized outcomes [13] and associated business-case models linking the value of benefits realized to the costs invested in the initiatives.

The CeBASE Method at the Organizational Level

The resulting organization (or portfolio) shared vision (OSV) (Figure 4) drives two sets of initiatives. Horizontally in Figure 4, it drives initiatives to improve software cycle time or to reduce order-delivery time across the organization. These initiatives will have strategy elements and their associated organization-level improvement plans (OP) such as reducing delays in order-delivery time due to software defects.

Following the GQM paradigm, the goal of reducing order-delivery time is related to organization plan questions such as, “What is our current record on delivery times?” “What distinguishes orders with significantly better or worse delivery times?” “What are the costs and benefits resulting from an improvement initiative?”

These questions are related to metrics such as overall order-delivery time, critical-path task times, costs and benefits of eliminating related software defects, and customer order-delivery satisfaction ratings. These are used to monitor and control organization-level process improvement (OPC), and to adjust the strategies and goals based on the organizational feedback of progress/plan/goal achievements and mismatches.

The CeBASE Method at the Project Level

Vertically in Figure 4, the OSV drives the nature of each project’s shared vision (PSV) and its associated goals and priorities. Thus, for example, an organizational improvement goal to reduce software development cycle time by 50 percent will be reflected in the project’s value propositions and improvement goals or the organization project shared vision (O-PSV) (see arrow in Figure 4). This will lead to project-level goals, models, questions, and metrics such as reducing the duration of each project task by 50 percent.

This in turn leads horizontally across the bottom of Figure 4 to project-level plans (PP), project monitoring and control activities (PMC), and to the determination and feedback of project-level progress/plan/goal mismatches. This mismatch feedback could be negative such as increased integration and test task durations or it could be positive. For example, the project might incorporate a new in-transit-visibility COTS package for order delivery tracking that both helps in delay diagnosis and improves customer satisfaction by answering questions about delivery delays.

This project feedback propagates upward to the organizational level along all three lines of traceability. The shortfalls or

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
opportunities with respect to organizational shared vision and goals are fed back along the project OSV (P-OSV) arrow at the left. The corresponding plan-context feedback occurs along the project OP (P-OP) arrow in the center; and the monitoring and control feedback at the right is used to update the organization’s detailed experience base on best practices for achieving goals.

As a final observation, note that the content of the PP element consists of the Spiral/MBASE Life-Cycle Objectives (LCO), Life-Cycle Architecture (LCA), and Initial Operational Capability (IOC) anchor-point milestone content that we discussed in our May 2001 and December 2001 CrossTalk articles [1, 2]. Thus, the Spiral/MBASE guidelines in those articles have become the project-level guidelines for the CeBASE method. A detailed example of these guidelines is shown next.

### CeBASE Guidelines Example: Shared Vision

The CeBASE project-level and organization-level shared vision guidelines are quite similar. Their main difference is one of context: The project-level shared vision has the organization-level shared vision as context and shows traceability to it, but not vice versa. Figure 5 shows the table of contents and example text from the project-level shared vision guidelines.

In the CeBASE method, it is the first item to be drafted by the project’s Integrated Product Team of success-critical stakeholders or its equivalent. It sets the stage for subsequent Inception Phase prototyping and stakeholder win-win requirements negotiation.

The shared vision guidelines are adopted from best commercial practices in ways that apply to public service applications as well. The system capability “elevator” description comes from Geoffrey Moore’s Crossing the Chasm [13]. The “Benefits Realized” and “Results Chain” sections are adapted from the DMR Consulting Group’s Benefits Realization Approach [14]. The Results Chain identifies the full set of initiatives necessary to realize the proposed system’s benefits; this also identifies the full set of success-critical stakeholders who should be involved in the system’s definition. The current version of the guidelines is at <http://cebase.org/cebase_method>.

### CeBASE Method Coverage of the CMMI

#### Example Mapping: Requirements Development

To test its coverage of critical issues, we have done a mapping of the CeBASE method onto the CMMI’s 24 process areas using the CMMI summary tables in Ahern, et al. [15]. A mapping example is provided in a longer version of this paper available at <http://www.cebase.org>.

Overall, the mapping indicated that the CeBASE method covered the CMMI’s goals and practices well. It provided the CeBASE team with some action items to address missing elements covered in the CMMI. Most significantly, though, it identified items that we have found important to software and systems engineering that were missing in the CMMI. These included a business case justifying the need for required features, having a stakeholder win-win prioritization of requirements (for coping with new requirements and fixed budgets or schedules), coverage of project requirements (required platforms, resource constraints), level of service requirements (the -ilities), and evolution requirements (to avoid point-solution architectures).

### Overall CeBASE Method Coverage of the CMMI

Overall, we found not only a strong correspondence but also an almost complete coverage of the CMMI’s practices by the organizational and project components of the CeBASE method. We are extending the CeBASE method to cover the specific CMMI processes not currently covered. A summary of the percentage of the CMMI process areas covered by the CeBASE method is shown in Table 1 (see page 14). The “+” annotations in Table 1 indicate that the CeBASE method’s coverage goes considerably beyond that of the CMMI. For example, it covers not just an organizational process focus but also an organizational product and people focus. The “-” annotations in Table 1 indicate that some areas in the CeBASE method still remain to be fleshed out, such as detailed guidelines for organizational training plans, although they are covered in principle. The CeBASE method also provides a prescriptive approach for an organization to use in tailoring the CMMI’s generic practices to its particular culture, environment, and value propositions. Thus, an e-commerce organization’s value propositions (rapid time to market, rapid adaptation to change) will...
cause it to adopt more flexible processes. However, such elements as the anchor-point milestones will balance this flexibility with sufficient discipline to keep the overall process under control. The value propositions of an organization developing safety-critical products or services will cause it to emphasize more rigorous specifications, processes, and practices, but in ways that enable it to cope with rapid change. Examples include capturing evolution requirements, designing systems to accommodate future change, building in buffer periods to synchronize and stabilize processes [16], or to adapt to potential schedule or budget slips by dropping lower-priority product features [3].

Another point worth emphasizing is that the EF component of the CeBASE method supports a continuous vs. staged approach to process improvement. You do not need to be a CMM Level 4 organization to begin realizing significant benefits from organizational innovation or causal analysis.

### Using the CeBASE Method

Since 1996, we have been applying the EF and GQM approaches to improve the project-oriented MBASE aspects of the CeBASE method by using them to improve an annual series of USC electronic services projects. These are developed using annually improved MBASE guidelines by teams of five master’s-level students as developers and staff members of USC’s Information Services Division as clients (customers, users or user representatives, and maintainers). Each year, we have 15 to 20 teams execute the MBASE inception and elaboration phases in the fall semester to develop and validate life-cycle architecture packages for USC electronic services applications’ candidates. The top six to 10 of these applications are then selected for spring semester teams who execute the MBASE construction and transition phases and deliver initial operational capability application systems.

Our shared vision for the USC Center for Software Engineering’s research and education goals incorporates the win conditions of not only our students and their project clients, but also other stakeholders such as the center’s staff and prospective technology users, represented by our 35 industry and government affiliate organizations [17]. Our questions and metrics include stakeholder critiques of each project and extensive instrumentation of the projects’ effort, schedule, quality, productivity, and behavioral characteristics [18, 19, and 20].

Table 2 summarizes four years’ experience to date in applying and refining CeBASE on an annual selection of real-client projects.

A few explanatory comments on Table 2 are in order. The number of LCA teams is larger than the number of IOC teams because USC’s fall course is a core course for the USC master’s of science degree in computer science and has a much larger enrollment than the spring course, which is only required for a few specialization areas. In 1996-97, the subset of projects to be continued in the spring was primarily those having students continuing from the fall course. After we found that most of the 1996-97 products went unused, we performed a critical success factor analysis and determined a set of spring project selection criteria (e.g., library commitment to product use, empowered clients) that increased the project adoption rate. Even then, unforeseen circumstances such as the inevitable changes in library infrastructure and organizational responsibilities have caused some applications’ usage commitments to be overtaken by events. This is a frequent phenomenon for electronic services applications [21].

In general, the EF improvements on MBASE have effected a uniform improvement in outcome, but there are some anomalies. For example, the 12 percent of projects failing IOC in 1999-2000 were due to a team who botched their product transition when their client was unexpectedly called out of town during the transition period. Another example was our introduction of midcourse client briefings on core capability expectations in 1999-2000 as part of our SAIV process [3]. SAIV only guarantees the delivery of a highest-priority core capability set of features, with further features added as time is available. While this resulted in early client disappointments at LCA where client success scores dropped from 4.74 in 1998-1999 to 4.48 in 1999-2000, there was a dramatic increase in the clients’ success score for the delivered product (4.3 in 1998-1999 to 4.75 in 1999-2000).

The 1998-99 improvement in the “Failing LCO” criterion shown in Table 2 resulted primarily from our introduction of a simplifier and complicator (S&C) expectations management activity. This helped the developers to have a better understanding of the system and the stakeholders by leveraging an experience base of designs that help simplify the architecture (the simplifiers) and apply a risk-driven approach to the architectural areas that may cause significant complications (the complicators). Involving the clients in risk management activities throughout the process clearly contributed to their rating virtually all delivered applications as highly satisfactory.

### Conclusions

Figure 6 summarizes the distinctions among maturity models such as the SW-
CMM and the CMMI; process models such as the waterfall model; and process model
generators such as MBASE, RUP, and the CeBASE method. It shows where each
model fits with respect to organizational focus (project vs. organization), application
focus (software vs. system), and operational focus (practice vs. assessment).

From Figure 6, we can see that the SW-
CMM covers both project and organization
considerations, but it has shortfalls in both
applications focus (software, not systems)
and operational focus (assessment, not practice). We can also see that solutions
focused on redressing one of the two short-
fall dimensions will still have shortfalls of
their own in another dimension. Thus, the
CMMI redresses the systems shortfall in the
SW-CMM, but it still has the shortfall of
providing explicit guidelines for assessment
but not for project practices. While MBASE
and RUP provide explicit guidelines for
project practices, they do not provide coun-
terparts for an organization’s practices.
However, the combination of CMMI and the
CeBASE method covers all aspects of
operational, organizational, and application
focus.

In terms of future software-intensive
system challenges, the ability to balance dis-
cipline and flexibility is critically important
to the development of highly dependable
software-intensive systems in an environ-
ment of rapid change. The CMMI’s risk-
management orientation enables its users to
apply risk considerations to determine how
much discipline and how much flexibility is
enough in a given situation. The risk-driven
nature of the spiral model and MBASE
enables them to achieve a similar balance of
discipline and flexibility. When these proj-
ect-level approaches are combined with the
organization-level approaches in the EF, the
result is the unified CeBASE method sum-
marized in the section “The CeBASE
Method and the CMMI.” It currently imple-
ments most of the CMMI, is being extend-
ed to cover the full CMMI, and has a strong
track record of continuous process
improvement at USC’s and UMD’s
Software Engineering Laboratories and
industry adapters elsewhere.

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Figure 6: Process Model Coverage Distinctions

MBASE and CeBASE.

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About the Authors

Barry Boehm, Ph.D., is the TRW professor of software engineering and director of the Center for Software Engineering at the University of Southern California. He was previously in technical and management positions at General Dynamics, Rand Corp., TRW, Defense Advanced Research Projects Agency, and the Office of the Secretary of Defense as the director of Defense Research and Engineering Software and Computer Technology Office. Dr. Boehm originated the spiral model, the Constructive Cost Model, and the stakeholder win-win approach to software management and requirements negotiation.

University of Southern California
Center for Software Engineering
Los Angeles, CA 90089-0781
Phone: (213) 740-8163
Fax: (213) 740-4927
E-mail: boehm@sunset.usc.edu

Daniel Port, Ph.D., is a research assistant professor of Computer Science and an associate of the Center for Software Engineering at the University of Southern California (USC). Dr. Port's previous positions were assistant professor of Computer Science at Columbia University, director of Technology at the USC Annenburg Center EC2 Technology Incubator, co-founder of Tech Tactics, Inc., and a project lead and technology trainer for NeXT Computers, Inc. He received a doctorate from the Massachusetts Institute of Technology in applied mathematics with an emphasis on theoretical computer science in 1994 and a bachelor's degree in mathematics from the University of California in Los Angeles.

University of Southern California
Center for Software Engineering
Los Angeles, CA 90089-0781
Phone: (213) 740-8163
Fax: (213) 740-4927
E-mail: dport@sunset.usc.edu

Apurva Jain is a doctoral student at the University of Southern California's Center for Software Engineering. Previously he was a project manager at SpruceSoft Inc. His research interests are software process management and pervasive computing. He received a bachelor's degree from Curtin University of Technology, Perth, Australia and a professional honors diploma from Informatics, Singapore.

University of Southern California
Center for Software Engineering
941 W. 37th Place, SAL 329
Los Angeles, CA 90089-0781
Phone: (213) 740-6505
Fax: (213) 740-4927
E-mail: apurva@sunset.usc.edu

Victor R. Basili, Ph.D., is a professor of Computer Science at the University of Maryland, the Executive Director of the Fraunhofer Center, Maryland, and one of the founders and principals in the Software Engineering Laboratory. He works on measuring, evaluating, and improving the software development process and product and has consulted for many organizations. Dr. Basili is a recipient of a 1989 NASA Group Achievement Award, a 1990 NASA/GSFC Productivity Improvement and Quality Enhancement Award, the 1997 Award for Outstanding Achievement in Mathematics and Computer Science by the Washington Academy of Sciences, and the 2000 Outstanding Research Award from ACM Special Interest Group on Software Engineering.

Computer Science Department
4111 AV Williams Building
University of Maryland
College Park, MD 20742
Phone: (301) 405-2668
Fax: (301) 405-2691
E-mail: basili@cs.umd.edu
The importance of information security has increased substantially in the past few years, primarily due to the growth of the Internet. The events of 9/11 have resulted in a heightened awareness of the importance of information security in several key ways.

There is a greater need for information sharing than ever before to enable disparate intelligence, military, and law enforcement groups to selectively share information, yet maintain “need-to-know” provisions required by national security. There is an increased awareness of the threats posed by information warfare; without ever firing a shot, enemy forces could launch a cyberattack on a nation’s critical infrastructure, thus rendering a foe helpless.

The importance of information security to the U.S. armed forces is thus both old and new. Its importance is old in that the problems of information security are, as they have always been, related to the confidentiality, integrity, and availability of information (the “CIA” of traditional information security). Its importance is new in response to cyberwarfare threats, the sheer volume of computerized information, and the numbers of people accessing it. U.S. Department of Defense (DoD) requirements for information security include all of the following:

- Large diverse worldwide user community.
- Coalition forces’ need for interoperability.
- Enforce “need-to-know” while enabling greater data sharing.
- Highly secure communications.
- Stringent auditing requirements.
- Users access to multiple systems to carry out their mission.
- Critical nature of many defense systems requires 100 percent uptime.
- Independent measures of assurance as required by federal directives.

An explanation of each information security requirement follows below.

**DoD Information Security Requirements**

**Large User Communities**

The DoD represents an extremely large diverse worldwide user community. The sheer size of the user community accessing defense systems via the Web not only increases the risk to those systems, but also constrains the solutions that can be deployed to address that risk. Moving applications to the Web creates challenges in terms of scalability of security mechanisms, management of those mechanisms, and the need to make them standard and interoperable. Whereas the largest traditional enterprise systems typically supported hundreds of users, many Web-enabled defense systems have potentially thousands of users.

**Secure Communications**

Unlike traditional defense systems where a command or program owns and controls all components of the system, Web-enabled systems must exchange data with systems owned and controlled by others, e.g., other commands, suppliers, coalition forces, partners, etc. Security mechanisms deployed in these systems must therefore be standards-based, flexible, and interoperable to ensure that they work with others’ systems. They must support thin clients and work in multilayer architectures.

**Enforce Need to Know**

Allowing greater access to data while enforcing need to know means that access control must be enforced on the data to ensure that the same security policy is enforced regardless of the method of data access. This requires a high degree of granularity in traditional access control mechanisms, as well as the ability to compartmentalize data access based on an application-specific security classification. (Application-specific meaning that organizations may have different data labeling requirements, and thus cannot necessarily use a fixed-labeling scheme across every organization that needs access to the same data). Real-time information sharing requires real-time or near real-time reclassification of data, so that, as threats change, information can be both shared and segmented among the multiple constituencies who need access to it.

"Without ever firing a shot, enemy forces could launch a cyberattack on a nation’s critical infrastructure, thus rendering a foe helpless."
and slows down system performance). However, there is a requirement for selective encryption of some stored data as an extra layer of protection, for defense in-depth.

**Stringent Auditing**

The more sensitive the data, and the more users with access to that data, the greater the requirement to hold users accountable through auditing. Unfortunately, a number of serious security breaches involving national security might have been prevented had proper auditing mechanisms been enforced. Auditing must be granular enough to focus upon a particular activity, user, or object, and comprehensive enough to record all user activity of interest, yet have minimal impact on performance. Auditing must also be tied into an alert mechanism to provide administrators with timely information.

**User Access to Multiple Systems**

Traditional mechanisms used to identify users and manage their access like granting each user an account and password on each system they access are not practical in a large interconnected environment such as organizational intranets or the Internet. It rapidly becomes too difficult and expensive for system administrators to manage separate accounts for each user on every system. There is a greater requirement for both strong user authentication - due to the increased amount of information users are able to access - and central identification and management of users due to the prohibitive cost of managing access for thousands if not hundreds of thousands of users across multiple systems. Furthermore, in the case of non-centralized account and privilege administration, shutting down or restricting a user's access in the event of a suspicious security event or security breach is time consuming. It also exposes the systems to additional breaches while the administrator is required to access and modify each separate system.

**Availability**

System availability is critical due to the nature of the mission of the U.S. armed forces. More than perhaps any other consumers of information technology, DOD systems require 100 percent uptime. For most commercial organizations, information unavailability during system downtime may be inconvenient and costly but not life threatening. For the armed forces, information availability may literally be the difference between mission success or failure and life or death.

**Information Assurance**

U.S. federal directives such as the National Security Telecommunications and Information Systems Security Policy (NSTISSP) No. 11, (see [www.nstissc.gov/assets/pdf/nstissp11.pdf](http://www.nstissc.gov/assets/pdf/nstissp11.pdf)) require information systems that access or manage information related to national security to have independent measures of information assurance, as evidenced by formal, independent (third-party) security evaluations. Acceptable criteria against which products may be evaluated include the Common Criteria ISO-15408 (see [http://csrc.nist.gov/cc/ccv20/ccv2list.htm](http://csrc.nist.gov/cc/ccv20/ccv2list.htm)), the de facto worldwide evaluation criteria, and the Federal Information Processing Standard (FIPS)-140 (see [http://csrc.nist.gov/cryptval](http://csrc.nist.gov/cryptval)), which attest to the correctness of cryptographic mechanisms.

In the past, procurement vehicles specified formal security evaluations. Many requiring a solution compliant with the Trusted Computer Security Evaluation Criteria (see [www.radium.ncsc.mil/tpep/library/tcsec](http://www.radium.ncsc.mil/tpep/library/tcsec)) or an Evaluation Assurance Level 4 (EAL4), as defined in the Common Criteria, were often granted waivers for this requirement based on functionality requirements that were not supported in the evaluated versions. Procurement waivers (from NSTISSP No. 11 requirements) will likely - and rightly - be much harder to acquire in a security environment after 9/11. Security will play a stronger role in the tradeoff analysis between security and functionality.

This article describes both the appropriate technical measures as well as specific security mechanisms that can address the above requirements (in general terms). Since many Web-based information-processing systems are built on database management systems, the technical solutions will be presented in terms of the protection of information stored in database systems.

**Technical Solutions**

**Large User Communities**

Most organizations face daunting obstacles in user management. Users within an organization often have far too many user accounts, with each system that controls sensitive material having a separate authentication procedure. This problem has been exacerbated by the growth in Web-based self-service applications - every other week, users have a new user account and password to remember. Organizations who want per-user data access and accountability do not want the administrative nightmare of managing users in each database or application users access. An organization opening its mission-critical systems to partners and consumers does not want to create an account for each partner in each database, the partner accesses, yet per-partner privilege and per-partner accountability is highly desired.

An increasing number of products view directories as the best mechanism to make enterprise information available to multiple different systems within an enterprise. The trend toward directories has been accelerated by the growth in use of the Lightweight Directory Access Protocol. These directories contain the user's identity information, as well as their roles and privileges to perform operations. Enterprise roles, roles that are defined across an enterprise and that apply to multiple applications, enable strong centralized user authorization. Also, an administrator can add capabilities to enterprise roles (granted to multiple users) without having to update each user's authorizations independently.

Storing this information in a central repository allows the administrator to grant and remove privileges that impact all of the organizational resources. Directory information that specifies users' privileges or access attributes is sensitive since unauthorized modification of this information can result in unauthorized granting or denial of user privileges or access. A directory that maintains this organizational information must ensure that only authorized system security administrators can modify privileges or access directory information.

**Secure Communications**

Communication mechanisms must support both confidentiality and data integrity requirements. It is important to secure the communications against network snooping.
and data replay or modification (altering data on the wire or removing information during transmission). Network encryption, including both confidentiality and integrity algorithms, is a standard method for ensuring secure communications.

In the case of client-server Web-based applications, it is important to support encryption from the client browser to the middle-tier Web application server. Using Secure Sockets Layer Version 3 (SSL V3) has become accepted technology for this purpose. SSL provides authentication, integrity, and encryption services using public-key encryption.

It is also important to support encryption from the middle tier to the database. This can be provided through a variety of mechanisms, including both native encryption technology in database products and using SSL. Because different algorithms provide different features and assurance, it is important to support a variety of industry-standard encryption algorithms to protect the confidentiality of data: for example, the Data Encryption Standard (DES, see <www.itl.nist.gov/fipspubs/fip46-2.htm>); triple DES (see <http://csrc.nist.gov/cryptval/des.htm>); and RC4 (see <www.rsasecurity.com/rsalabs/faq/3-6-3.html>). Also, use integrity algorithms to verify that data have not been modified, including Secure Hash Algorithm (SHA)-1 (see <http://csrc.nist.gov/sshval/shs.htm>) and MD5 (see <www.rsasecurity.com/rsalabs/faq/3-6-6.html>).

The Federal Information Processing Standard (FIPS) 140-1, Security Requirements for Cryptographic Modules, was established to validate encryption products purchased by the U.S. government. Products are validated against FIPS 140-1 at security levels ranging from level one (lowest) through level four (highest). A FIPS validation ensures that the implementation of an encryption algorithm has been properly tested.

Auditing
A critical aspect of any security policy is maintaining a record of system activity to ensure that users are held accountable for their actions and that they do not abuse their privileges. Auditing implementations can and do vary by vendor; the following describes Oracle's auditing capabilities. Auditing options need to be highly granular to target the user actions of interest, to minimize the performance overhead of auditing, and to avoid analysis paralysis, in which there are too many auditing records to facilitate meaningful inspection. Ideally, audit records include enough granularity that an administrator can determine what the user requested as well as what was returned to the user at the time of the original request.

A robust database audit facility will allow organizations to audit database activity by statement, by use of system privilege, by object, or by user. One can also audit only successful or unsuccessful operations. For example, auditing unsuccessful SELECT statements may catch users on fishing expeditions for data they are not privileged to see. Database system logs that capture all changes to the database (required for recoverability of data) can be accessed for this purpose. The granularity and scope of these audit options allow customers to record and monitor specific database activity without incurring the performance overhead that more general auditing entails.

A needed auditing capability is one that enables organizations to define specific audit policies that can alert administrators to misuse of legitimate data access rights. What is desired is the ability to define audit policies, which specify the data access conditions that trigger the audit event and are tied to a flexible event handler to notify administrators (e.g., via a page) that the triggering event has occurred. An Oracle implementation of this feature captures the exact text of the statement the user executed in audit tables. In conjunction with other database features that reconstruct the result of a query at a past time, this auditing capability can be used to recreate the exact records returned to a user. A flashback or temporal query allows the recreation of the data a user accessed at the time of the original operation. This is an important feature for customers who wish to share information they wish to have, but with the assurance that sensitive information they wish to protect will remain confidential.

Need-to-Know Protection
The U.S. armed forces, as with many military and intelligence organizations, has a requirement to separate unclassified (but sensitive) information from classified information and to compartmentalize access to classified information. This includes the ability to limit data access based on an arbitrary, hierarchical data level (e.g., Secret, Top Secret), compartments (e.g., Project X), and control of its release (e.g., Releasable to United Kingdom).

During the 1990s, many vendors delivered products that provided multilevel security (MLS): the ability to enforce mandatory access control based on the comparison of a user's clearance to a label on the data. For example, a database containing products required for a joint military exercise with coalition partners could contain data that were viewable only by the United States, particular coalition partners, or all parties. The database would both separate the data and control access based on user clearance. However, MLS systems had a very low rate of adoption even among the user communities (DoD) who had the requirement for such systems.

At the same time, MLS systems were failing to be adopted by the markets that had demanded them; commercial organizations were taking advantage of the accessibility of the Internet to become e-businesses. Many commercial companies that wanted to open mission-critical systems to partners and customers over the Internet had an increased requirement for granular access control to the user or customer.

Companies offering application-hosting services also faced unique security challenges such as keeping data from different hosted user communities separate. The simplest way of doing this is to create physically separate systems for each hosted community; the disadvantage of this approach is that it requires a separate computer with separately installed, managed, and configured software for each hosted user community, providing little economies of scale to a hosting company. Business-to-business exchanges also faced requirements for both data separation and data sharing.

To address both the Internet requirements for data separation and data sharing and government requirements for granular access control, Oracle introduced the abil-
ity to provide programmable row-level access control. This capability called Virtual Private Database (VPD) is server-enforced, fine-grained access control together with a secure application context, enabling multiple customers and partners to have secure direct access to mission-critical data. VPD enables, within a single database, per-user or per-customer data access with the assurance that enforcement is not able to be bypassed. The result is a lower cost of ownership in deploying applications since security can be built once in the data server rather than in each application that accesses the data. Security is stronger because it is enforced by the database: No matter how a user accesses data, security policies cannot be bypassed.

VPD can be built upon to support specific application policies. One such policy implementation developed by Oracle addresses the DoD and intelligence community requirement to automatically provide labeled data management and enforce label-based and compartmentalized data access. This policy implementation allows organizations to assign sensitivity labels to information, control access to that data based on those labels, and ensure that data are marked with the appropriate sensitivity label. For example, a counterterrorism application may separate data for “need-to-know” purposes based on selected agencies or groups within agencies (e.g., Secret: CIA, Defense Intelligence Agency). The ability to natively manage labeled data speaks to cryptographic module validation and the international Common Criteria, which is a formal security evaluation standard.

Standards

The existence of and adherence to standards enable stronger security of an integrated system. Security standards are especially important since security generally needs to be integrated to work; there are very few security bolt-ons that can enhance or enable security that do not already exist in the underlying components. Security standards also facilitate the secure integration of disparate technology components.

Standards also usually result in a lower cost of ownership because integration costs are lower (more things work together out of the box), and component costs are generally lower if the products are differentiated on something other than proprietary, lock-in technology. In general, the price is high, and the quality (especially security, which tends to be costly to build) is lower in a monopoly or near-monopoly market.

It is especially important for the DoD to ensure interoperability between entities within one of the armed forces, among the various armed forces, and with coalition partners’ systems.

Another benefit of standards is that there tends to be less security by obscurity, the security mechanisms, if they comply with a standard, are well-known rather than hidden and can also be certified or evaluated against the standard, thus providing consumers with confidence in the security of the resulting products.

Standards can include two types of technical interfaces. The first is the Public Key Certificate Standards (PKI, see \(<www.rsasecurity.com/rsalabs/pkcs>) and Public Key Infrastructure X.509 (PKIX, see \(<www.ietf.org/html.charters/pkix-charter.html>)

Second, are the independent measures of assurance for security components such as FIPS-140, which... a counterterrorism application may separate data for ‘need-to-know’ purposes based on selected agencies or groups within agencies ...

PKI is also very scalable technology; in theory, a user who has been given a set of PKI credentials attesting to his/her digital identity can authenticate to servers and systems that he/she has never connected to before because the user’s identity can be validated through PKI mechanisms. While this portability of credentials has limited practical application in many commercial organizations (realistically, Bank A will not accept user credentials issued by Bank B), the applicability within DoD is much more apparent. Each service member has precisely one identity as far as the U.S. armed forces is concerned. Once credentials are issued for that identity, they can be reused in multiple DoD systems.

The following are features that are important in database products to support PKI Infrastructure implementations:

- Client-based authentication using X.509 certificates stored in PKCS No. 12 containers. PKCS No. 12, titled Personal Information Exchange Format, specifies a standard for the transfer of identity information including private keys, certificates, etc.
- Wallets (PKI credential container) interoperable with third-party applications and portability across operating systems.
- Support for multiple certificates for each wallet, including Secure Multipurpose Internet Mail Extensions (S/MIME, see \(<www.rsasecurity.com/standards/smime>) signing certificates, S/MIME encryption certificates, and code-signing certificates.
- Client authentication using SSL. Since PKI at best provides a single set of credentials, but not single sign on, it is helpful to use PKI in conjunction with single sign-on services as described below.

**Single Sign On**

In client-server database applications, strong authentication, and single sign on (SSO) are important features. A variety of different user authentication mechanisms are used depending on the application requirements. These can include user passwords, smart cards, token cards, and biometric authentication devices. SSO is provided by technologies such as Kerberos (see \(<http://web.mit.edu/kerberos/www>)\), Distributed Computing Environment (see \(<www.osf.org/dce>)\), and SSL.

Web-based SSO encompasses a different set of security issues than client-server SSO due to the stateless nature of Web-based connections. One approach to dealing with this problem is to use a central-
Availability

Databases and the Internet have enabled worldwide collaboration and information sharing by extending the reach of database applications throughout organizations and communities. This reach further highlights the importance of high availability in data management solutions. Small businesses and global enterprises alike—let alone the U.S. armed forces with their obvious need for high availability to support national security missions—have users all over the world requiring access to data 24 hours per day. Data availability includes the capacity to recover from unplanned outages, allowing planned database maintenance while the database is in production and available to users, improve system manageability and serviceability, and provide enterprise-class disaster planning. Highly available solutions have three basic characteristics:

- Reliability: Reliable solutions are made of components that seldom fail.
- Recoverability: In the event a component does fail, a highly available solution quickly recovers without human intervention.
- Continuous Operation: Highly available solutions continue to provide service, even during maintenance activities.

Each component in a system should be designed to provide high availability, which means each component is reliable. In addition, each component must be able to recover from failures of supporting components in the stack. The frequency of failures and the speed of recovery determine the amount of unplanned downtime and application experiences. However, unplanned downtime is not the complete story. Each component must be able to provide continuous operation to meet an acceptable planned downtime target. This may require designing and building the system so that preventative maintenance can be performed while the application is online and users are accessing data. It is also important to plan for unforeseen incidents such as earthquakes and power outages that may prevent recovery for an extended period of time.

One of the true challenges in designing a highly available solution is examining and addressing all the possible causes of downtime. It is important to consider causes of both unplanned and planned downtime, including middleware, application, and network failures. Unplanned downtime can include component failure; hardware failures include system, peripheral, network, and power failures. Human error, a leading cause of failures, includes errors by an operator, user, database administrator, or system administrator. Another type of human error that can cause unplanned downtime is sabotage. The final category is disasters. Although infrequent, these causes of downtime can have extreme impacts on enterprises because of their prolonged effect on operations. Possible causes of disasters include fires, floods, earthquakes, power failures, and bombings. A well-designed, high-availability solution will account for all these factors in preventing unplanned downtime. Planned downtime can be just as disruptive to operations, especially in the DoD, which must support users in multiple time zones up to 24 hours per day. In these cases, it is important to design a system to minimize planned interruptions.

Databases systems are designed to address the causes of unplanned and planned downtime. In the event of a failure, a database can quickly and automatically recover: No committed data are lost. In addition, database systems support features that obviate the need for planned downtime, allowing administrators to perform many management and maintenance tasks while the system is online and data are fully accessible. Management tools are available that identify potential problems and rectify them before they affect data availability.

Assurance

It is important not only to support security features but also to have validation that the features have been implemented in a correct and secure manner: This is provided by formal and independent security evaluations. A commitment to past and continuing product evaluation of new releases against the Common Criteria (ISO-15048) and encryption technology against FIPS 140-1 is a proven measure of a product vendor’s commitment to security. This level of commitment should be a requirement for use by the most security-conscious customers in the world: governments, defense, and intelligence agencies. The database, however, is only part of an enterprise-wide, end-to-end security model. A comprehensive approach to security, i.e., a multilayered distributed enterprise, is important to satisfying the mission of large government customers like the U.S. armed forces.

Conclusion

The DoD has a requirement for secure, interoperable, and available systems. While additional technical research and advancement will improve available security technology, much of the security technology needed to meet the DoD security requirements exists today. What is required is a commitment to use the security technology that exists, to demand secure and independently evaluated solutions, and to incorporate security into the entire computing infrastructure.

About the Author

Kevin J. Fitzgerald is senior vice president, Oracle Corporation Government, Education and Healthcare. He has been a leader in information technology sales and sales management for more than 25 years. Fitzgerald previously worked for Oracle from 1987-97 as vice president and general manager of the public sector sales group. During his initial tenure, he served in a number of sales roles and also helped initiate new product development areas and product enhancements, enabling Oracle to meet specialized government requirements. Fitzgerald served in the U.S. Air Force and has a bachelor’s degree from Boston College.

Point of Contact: Tracy Strelser
1910 Oracle Way
Reston, VA 20190
Phone: (703) 364-6118
Fax: (703) 364-3026
E-mail: tracy.strelser@oracle.com
What is Software Quality Assurance?

Dr. Linda H. Rosenberg
NA SA

Software directly impacts not only mission success but also mission safety. Software Quality Assurance (SQA) is critical to the success of every mission at NASA, but the roles and responsibilities are often misunderstood. SQA covers all phases of the software development process, including safety, reliability, independent verification and validation, and metrics. The purpose of this article is to help the reader understand software quality assurance.

Within the complex systems developed throughout the aerospace industry, software is playing an increasingly important role in mission success. Methods for developing and assuring software are often not well understood by program managers and, thus, are often simply ignored. In such a case, ignorance is far from bliss; it is dangerous. During the past few years, NASA has emphasized the faster, better, and cheaper approach to developing missions, thereby making it more important than ever to ensure the quality of its software products. It is this imperative that makes the role of Software Quality Assurance (SQA) critical in the short term, but also linked to mission success in the long term.

Assuring software quality requires that engineering knowledge and discipline be applied at all phases of the development life cycle. And just as with hardware, the final step in developing quality products culminates in rigorous testing before release. Quality assurance engineers are also required to possess sufficient domain knowledge to evaluate the completeness and correctness of system requirements, and they must have the ability to determine whether the design has incorporated all requirements accurately. Ultimately, these specialists are responsible for advising management when or whether a product is reliable and meets quality standards.

This article starts by discussing what is meant by SQA. It then discusses the aspects of how software quality assurance is applied to both the products and the process. The article continues with some of the major components of software assurance. Software metrics are used to help numerically determine the quality of the products, noting they are underutilized and often poorly understood. Another area of quality assurance not well understood is independent verification and validation (IV&V); this article will touch briefly on the role it plays in quality assurance. Finally, it discusses the ways in which software safety and reliability are assessed from a quality perspective. These two areas are often neglected despite their critical role in mission success.

**Definitions**

Software quality assurance is a combination of three concepts: quality, software quality, and software quality assurance.

"In the real work of software development, criteria for quality are identified and applied to differing extents as a result of trade-off decisions."

While the terms are often used interchangeably, we need to understand the basics of quality before we can understand the components and problems of software quality assurance.

**Quality Defined**

Before defining software quality, we need to define what is meant by quality. The Institute of Electrical and Electronics Engineers’ (IEEE) Standard Glossary of Software Engineering Terminology defines quality as "the degree to which a system, component, or process meets (1) specified requirements, and (2) customer or user needs or expectations [1]." The International Standards Organization (ISO) defines quality as "the totality of features and characteristics of a product or service that bear on its ability to satisfy specified or implied needs [2]." IEEE and ISO definitions associate quality with the ability of the product or service to fulfill its function. This is achieved through the features and characteristics of the product.

While this definition seems to be clear and unambiguous, the concept of quality really is not. Kitchenham states quality is "hard to define, impossible to measure, easy to recognize [3]." Gillies states that "Quality is generally transparent when present, but easily recognized in its absence [4]."

Therefore, while we can define quality in theory, in practice, and in use, an absolute definition is elusive.

**Software Quality Defined**

Software quality is defined in the Handbook of Software Quality Assurance in multiple ways but concludes with this definition: "Software quality is the fitness for use of the software product [5]." This definition implies the evaluation of software quality related to the specification and application of software quality. There are, however, criteria that help in the evaluation of software quality. For each project, the appropriate criteria need to be identified for the environment.

Two of the most often-cited models applying the criteria are the GE model proposed by McCall, which was later adapted by Watts, and the Boehm model [4]. Below is a combined list of definitions of quality criteria for software.

- Correctness: extent to which a program fulfills its specifications.
- Efficiency: use of resources execution and storage.
- Flexibility: ease of making changes required by changes in the operating environment.
- Integrity: protection of the program from unauthorized access.
- Interoperability: effort required to couple the system to another system.
- Maintainability: effort required to locate and fix a fault in the program within its operating environment.
• Portability: effort required to transfer a program from one environment to another.
• Reliability: ability not to fail.
• Reusability: ease of re-using software in a different context.
• Testability: ease of testing the program to ensure that it is error-free and meets its specification.
• Usability: ease of use of the software.

In a perfect world all of these criteria would be met, but software is not developed or run in such a world, and trade-offs are a part of all development projects. Often the most efficient software is not portable, as portability would require additional code, decreasing the efficiency. Usability is subjective and varies depending on the system users. When using the above criteria to define the assurance objectives of a software system, the purpose and use of the system must be taken into account. In the real work of software development, criteria for quality are identified and applied to differing extents as a result of trade-off decisions.

Software Quality Assurance Defined

Again referencing IEEE, quality assurance is defined as "a planned and systematic pattern of all actions necessary to provide adequate confidence that an item or product conforms to established technical requirements [1]." This definition needs to be adapted to software taking into account that, unlike hardware systems, software is not subject to wear or physical breakdown; consequently, its usefulness over time remains unchanged from its condition at delivery. Software quality assurance must be a systematic effort to improve the delivery condition. In the Handbook of Software Quality Assurance, the following definition is given: "Software quality assurance is the set of systematic activities providing evidence of the ability of the software process to produce a software product that is fit to use [5]." These activities are evaluated in part against the above criteria and measured as described in a later section of this article.

Software Quality Assurance Applied

The focus, therefore, of SQA is to monitor continuously throughout the software development life cycle to ensure the quality of the delivered product. This requires monitoring both the processes and the products. In process assurance, SQA provides management with objective feedback regarding compliance to approved plans, procedures, standards, and analyses. Product assurance activities focus on the changing level of product quality within each phase of the life cycle, such as the requirements, design, code, and test plan. The objective is to identify and eliminate defects throughout the life cycle as early as possible, thus reducing test and maintenance costs.

Process Assurance

It has been proven that the use of standards and process models has a positive impact on the quality of the final software. The purpose of standardization of SQA ensures that there is discipline and control in the software development process via independent evaluation [5]. ISO 9000 provided a way to gain external accreditation for a quality management system. Many companies have used the application of ISO to software, but the complaint is that it tends to fossilize procedures rather than encourage process improvement [4].

One of the most common software development models is the Software Engineering Institute’s Capability Maturity Model® (CMM®), which has recently developed into the CMM Integration® (CMMI®). The basic premise underlying both CMM and CMMI is that the quality of the software product is largely determined by the quality of the software development and maintenance processes used to build it [6].

Many commercial standards are also found in common practice for software development. Many organizations such as The Department of Defense and NASA have, in the past, developed their own standards for software development, but recently have embraced the use of commercial standards instead. It is now NASA’s policy to use commercial standards whenever possible, thus encouraging more standardization not only across NASA but within industry also.
requirements to be ambiguous and hence difficult to test and to identify any requirements that are incomplete [7].

It is up to the SQA organization to be cognizant of available and relevant metrics that help evaluate and assure products. When projects consistently use software metrics as part of their development, the SQA team needs only to validate the metrics and ensure the correct data interpretation. If a project is not employing metrics, however, then it is the responsibility of SQA to encourage, and perhaps facilitate, their use or to develop an independent metrics program for sufficient insight into the development.

**Independent Verification and Validation**

IV&V is defined by three components; it must be independent technically, managerially, and financially. IV&V must prioritize its own efforts, identifying where to focus its activities. It must have a clear reporting route to the program management, and the budget for these efforts must be allocated and controlled by the program. Control must occur at a level that is independent of the development organization such that the effectiveness of the IV&V activity is not compromised.

Verification is defined as the process of determining whether or not the products of a given phase of the software development cycle fulfill the requirements established during the previous phase, i.e., whether or not it is internally complete, consistent, and correct enough to support the next phase. Validation is the process of evaluating software throughout its development process to ensure compliance with software requirements. Verification often asks the question, “Are we building the product right?” Validation asks, “Are we building the right product?”

NASA has a facility in West Virginia whose primary purpose is the accomplishment of IV&V. Without SQA, IV&V is expensive and often less effective. Where SQA is a broad blanket across the project, overseeing all process and product activities, including software, IV&V focuses on only those processes and products determined to have the highest risk and does an in-depth evaluation of them.

**Safety**

Safety is a team effort and is everyone’s responsibility. Software is a vital part of the system. Project managers, systems engineers, software leads and engineers, software assurance or quality assurance (QA), and system safety personnel all play a part in creating a safe system. Safety-critical software is defined by the NASA Software Safety Standard as “Software that directly, or indirectly, contributes to the occurrence of a hazardous system state, controls or monitors safety critical functions, runs on the same system as safety critical software or impacts systems that run safety critical software, or handles safety critical data [8].” The goal is for the QA activity to ensure that software contributes to the safety and functionality of the whole system.

When a device or system could possibly lead to injury, death, or the loss of vital (and expensive) equipment, system safety is always involved. Often hardware devices are used to mitigate the hazard potential or to provide a fail-safe mechanism should the worst happen. As software becomes a larger part of electromechanical systems, hardware hazard controls are being replaced or backed up by software controls. Software has the ability not only to detect certain types of error conditions more quickly than hardware but also to respond more intelligently, thereby avoiding a potentially hazardous state. The increased reliance on software means that the safety and reliability of the software become vital components in a safe system [8].

**Reliability**

IEEE defines software reliability as “The probability that software will not cause the failure of a system for a specified time under specified conditions. The probability is a function of the inputs to and use of the system, as well as a function of the existence of faults in the software [9].” Using this definition, expectations of reliability must be based on how the system is to be used and for what length of time. At NASA, many of our satellites fly for multiple years; the reliability of their software must support the expected lifetime. The conditions of that software’s use will be specified by the satellite’s mission.

IEEE continues to define software reliability management as “The process of optimizing the reliability of software through a program that emphasizes software error prevention, fault protection and removal, and the use of measure- ments to maximize reliability in light of project constraints such as resources, schedule, and performance [9].” This definition puts the burden of reliability not just on the testing phase, but on the entire life cycle to ensure errors are prevented starting in the requirements phase determining the quality of such attributes as phrasing, completeness, and clarity. Throughout the life cycle, errors should be detected and removed using such techniques as code walkthroughs and inspections. Relevant measurements should be used at all phases to ensure the effectiveness of all assurance activities. In the testing phase, reliability can be evaluated using one of the many reliability models. These models, however, must be applied with very strict rigor to ensure accuracy. It is the responsibility of the SQA organization to ensure that reliability is continuously promoted and evaluated throughout the life cycle as specified above. Quality cannot be tested in at the end of a project; it must be built in as the software is being developed. Reliability also impacts safety—a system cannot be deemed safe if it is not reliable.

**Conclusion**

SQA is faced with many challenges starting with the method of defining quality for software. There needs to be a common understanding as to what is high-quality software, but the software usage environment usually influences the final definition. There are many aspects of SQA, from those within the phases of the software development life cycle to those that span multiple phases, i.e., safety, reliability, and IV&V. SQA is a very complex area that is critical to the ultimate success of a project; it is also one that requires a rather diverse set of skills. New knowledge areas such as software safety and reliability are now being added to the core set of required skills. Finally, SQA must be independent from development organizations to be successful.

**References**


Note

About the Author
Linda H. Rosenberg, Ph.D., serves as the chief scientist for Software Assurance for Goddard Space Flight Center, NASA. She is a recognized international expert in the areas of software assurance, software metrics, requirements, and reliability. Dr. Rosenberg has a doctorate degree in computer science, a master’s of engineering science degree in computer science, and a bachelor’s of science degree in mathematics.

Office of Systems Safety and Mission Assurance
Goddard Space Flight Center, NASA
Building 6 Code 300
Greenbelt, MD 20771
Phone: (301) 286-0087
Fax: (301) 286-1667
E-mail: linda.h.rosenberg@gsfc.nasa.gov

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Kasey Thompson, Program Manager • 801 775 5732 • DSN 775 5732
Dave Berg, Deputy Program Manager • 801 777 4396 • DSN 777 4396
Fax • 801 777 8069 • DSN 777 8069 • Web Site • www.jovial.hill.af.mil

What is Software Quality Assurance?
Capture/playback tools make it possible to repeat two or more tests identically and compare the results. This article focuses on capture/playback tools, which hold the largest market share of any tool category, and on examining trouble spots in test automation, dealing with them proactively and perhaps mitigating the risks of tool abandonment. The purpose of this article is to outline the 10 major challenges that the author sees most often in organizations struggling to make effective test automation a reality.

1. Lack of Tool Availability
   The lack of tool availability is usually the result of the following:
   1. The tool is available, but you cannot get the funding for it.
   2. There does not seem to be a tool on the market that does what you need or fits in your environment.
   
   The first issue is based in management's understanding of testing and the priority it is given in terms of funding. While the cost of automated test tools is high compared with more common software packages such as office automation products and software development suites, the anticipated value of the tools is in reduced time and greater testing precision. Test automation promises increased productivity and accuracy, which is where the business case must be made. The cost of a single defect in most organizations can offset the price of one or more tool licenses. It is all a matter of where management chooses to spend the money — in defect detection or post-production rework, which is many times more costly than early defect detection.

   Not having tools available in a particular environment is more troublesome. Although there is now automated tool support in most environments, this does not mean the support in every environment is great. In older environments, tool support is very limited.

   If funding is the issue, consider the following:
   • Measure the current cost of defects, especially in post-implementation rework. Use this information to help build a case for faster and more reliable testing using tools.
   • Show the value of automated test tools for other groups besides testers such as the value of developers using the tools.
   • If getting a good technical fit is the issue, consider the following:
     • Network with other testers to find information about lesser-known test tools. Online quality assurance forums are also good places to query people about tools in lesser-supported environments.
     • Try to find tools that will work between platforms. This will likely require the use of PC-based emulators as opposed to host-based tools.
     • Investigate the possibility of building your own tools or, at least, achieving a level of test automation using common scripting commands and comparison programs.

2. Lack of Tool Compatibility and Interoperability
   Tool incompatibility and lack of interoperability are seen in organizations that have diverse technologies and applications. The desire is to be able to auto-
The use of existing SCM tools currently owned by your organization.
- Trace your automated test scripts to functional requirements and defects.

4. Lack of a Basic Test Process or Understanding of What to Test
Most automated test tools do not tell you what to test. Even the tools that have test-case generation features do so at a user-interface level and not at the functional-requirements level.

If you do not know which tests are the most important and which tests are the most applicable for automation, the tool will only help perform a bad test faster.

Changes that impact the user interface will most likely require maintenance to the automated test scripts that test those interfaces.

Here are solution strategies for this challenge:
- During your tool search, consider the people and processes that will be required to manage the automated test cases and test scripts.
- If you are in the object-based environment (such as graphical user interfaces), look for tools that accommodate changes to the user interface gracefully. These tools cost more than those that do not offer such flexibility. However, many people have found that the added cost is small compared with the cost on continued manual maintenance of the test software.
- Consider automated test scripts as part of an application's configuration set.

Even, you still need the process and the people to make the SCM effort work. You can also build your own test management tool using a database and basic file organization to group related tests into suites.

A related issue is keeping up with changes to applications that are under test. This has been one of the biggest challenges in test automation since its inception. The degree of difficulty in dealing with application changes in automated testing software depends on the tool and the technologies involved. In the object-based world, the more robust tools can be configured to ignore user interface changes as long as the objects still behave the same. However, if the tool uses row-and-column positioning, then each application change will require a change (or many changes) to the automated test scripts.

In character-based applications such as mainframe Customer Information Control System applications, all of the effort is duplicated because different vendors are creating test scripts for single-use purposes.

You can also build your own test management tool using a database and basic file organization to group related tests into suites.

A related challenge is to automate identical tests on a number of different platforms. This requires tool compatibility among various computing platforms and the ability to share scripts between tools and platforms.

If compatibility and interoperability are the issues, consider the following:
- Select tools that have cross-platform capability to the greatest extent possible.
- Consider writing shell scripts and bridging scripts, perhaps in non-proprietary scripting languages such as Tcl.
- Evaluate critically whether the ability to perform cross-platform testing is a firm requirement.

3. Lack of Configuration Management Processes
Test automation is using software to test software. This means that items created using the automated test tools should be subject to the same level of control as any other software asset.

When software configuration management (SCM) is not in place for automated testing, the discipline is missing to work with the tools. The following occurs without SCM for automated test tools:
- Effort is duplicated because different people may each be building similar test scripts.
- Reuse is not realized because people are all creating test scripts for single-use purposes.
- Existing automated test scripts are at risk of corruption if they are modified without the knowledge of the original author.

Here are solution strategies for this challenge:
- Identify and manage the ownership, versions, and organization of the automated test scripts.
- Someone to own the SCM process and ensure that people are following it.

Many of the popular automated test tools have integrated test case and test script management applications. However, you still need the process and the people to make the SCM effort work. You can also build your own test management tool using a database and basic file organization to group related tests into suites.

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In character-based applications such as mainframe Customer Information Control System applications, all of the tools can be configured to ignore user interface changes as long as the objects still behave the same. However, if the tool uses row-and-column positioning, then each application change will require a change (or many changes) to the automated test scripts.

Let us say that I want to build a bookcase. I try cutting the wood with a handsaw, but it is far too slow and laborious. So, I decide to go to the hardware store and buy a power saw. After the purchase of the tool that I can afford, that looks good, or that the salesperson convinces me to buy, I go home and start cutting wood. However, if I do not have bookcase plans or a very good understanding of how to build a bookcase, the saw will just help me make my mistakes faster! To be successful, I will need to first learn enough woodworking skills to understand not only the "what" and "when," but the "why" and "how" of building the bookcase. Then, I’m ready to use the tool effectively.

The tool vendors can train you to use the tool with all of its functionality, but the burden is on you to examine your own applications and determine which functions should be tested and to what extent.

Here are solution strategies for this challenge:
- Create a set of evaluation criteria for functions that you will want to consider when using the automated test tool. These criteria may include the following:
  - Test repeatability.
  - Criticality/ risk of applications.
  - Operational simplicity.
  - Ease of automation.
  - Level of documentation of the function (requirements, etc.).
- Examine your existing set of test cases and test scripts to see which ones are
most applicable for test automation.
• Examine your current testing process and determine where it needs to be adjusted for using automated test tools.
• Be prepared to make changes in the current ways you perform testing.
• Involve people who will be using the tool to help design the automated testing process.
• Train people in basic test-planning skills.

5. Lack of Tool Ownership and Acceptance
The challenge with lack of tool ownership and acceptance is that the tool is not applied or is ignored. This is often the result of someone’s good intention of buying a tool to make life easier, but the rest of the people do not use it. The following are some of the reasons for lack of tool ownership and acceptance:
• Difficulty using the tool.
• Not enough time to learn the tool and still perform normal work levels.
• Lack of tool training.
• Lack of management support for tool use.
• Lack of tool support, either internally or from the vendor.
• Tool obsolescence.
Here are solution strategies for this challenge:
• Do not cut the tool training. Training does not guarantee success, but without it you are at risk of tool abandonment.
• Have someone in your organization in the role of a tool smith. This person’s job is to be the resident expert on the tools used for testing.
• Management needs to emphasize that the tool effort is important to them, and that tool usage is a required part of the testing process.

6. Inadequate Tool Training
We discussed the training issue previously in “Lack of Tool Ownership and Acceptance,” but this challenge carries its own set of concerns. Some of the key issues are as follows:
• Skipping the vendor’s training. The main motivation for this is lack of time and/ or money. You will spend more of both without the training!
• Not getting the right training due to the incorrect selection of topics. For example, some tool users will need to learn in detail the tool’s test scripting language, while other users will need to learn only the basic tool functionality.

7. Incomplete Coverage of Test Types
As you profile your tests and defect types, you will often find a wide variety of test types that need to be performed. These include tests for the following:
• Correctness.
• Reliability.
• Security.
• Performance.
• Usability.
• Interoperability.
• Compatibility.
• Data Conversion.

“Perhaps the greatest challenge seen in management support is balancing high expectations of tool benefits against the time, effort, and discipline it takes to implement the tool.”

Here are solution strategies for this challenge:
• Include money in the tool proposal for training at least a core group of people.
• Match people to the most applicable training topics.
• Have tool training performed by the vendor at your location using some of your own applications as exercises.
• Find a skilled local consultant experienced with the tool to sit with your team for about three to four weeks to help get you started in creating automated tests. It is very important that your team does most of the work to accomplish the transfer of knowledge!

8. Lack of Management Support
Management support is needed in designing and deploying test processes that will support the effective use of test tools, reinforce the role and use of automated test tools in the organization, and allow time for tools to be integrated in the testing process.

Without management support, the entire test automation effort is at risk. If management does not clearly and consistently show their support for test automation, people will be less inclined to show interest in using the tools. This is a major concern, especially considering that overcoming the learning curve of some tools requires dedication.

Perhaps the greatest challenge seen in management support is balancing high expectations of tool benefits against the time, effort, and discipline it takes to implement the tool. Management may become impatient about the lack of tool progress and shift their support to other initiatives.

The pressure is on the people who...
made the business case for the tools to show progress in a given timeframe. The problem is there are many unforeseen things that can delay or derail a tool initiative. In reality, if people fully knew all of the future problems with any given effort, they would be very reluctant to proceed. While there is a place for optimism in acquiring tools, a heavy dose of realism is also needed to keep expectations in line with what is achievable.

Here are solution strategies for this challenge:

- Communicate that it takes time and planning to build a firm foundation of people, processes, and the right tools.
- When making the case to management for acquiring test tools, present the challenges as well as the benefits.
- Reinforce to management that they carry a great deal of influence in how people will accept automated test tools.
- Keep management informed of tool progress and issues that arise.

9. Inadequate Test Team Organization

Most test organizations learn that automated testing is a new world in terms of how tests are designed and maintained. Most tests require more than just capture/playback. The tool user must also be able to work with the tool’s scripting language to accurately replay the test session. It helps if the tool user is comfortable working with coding languages, otherwise, there is a risk that the tool will not be used.

Here are solution strategies for this challenge:

- Add a person to the test team who is a test scriptor. This person should be comfortable in working with code and be able to take the basic test that has been designed by a test analyst and convert it into an automated script.
- Start simple with basic scripting concepts and add complexity later.

10. Buying the Wrong Tool

Buying the wrong tool is listed as the No. 1 challenge in test automation because no matter what kind of process or organization you have, if the tool is not a good technical or business fit, people will not be able to apply it.

We know that a good process and organization are also essential for test automation. However, if the tool will not function at a basic level, people using the tool will simply give up trying to use it.

Unfortunately, too few people do adequate research before buying a test tool. Adequate research includes defining a set of tool requirements based on what the intended users of the tool need to accomplish, developing a set of evaluation criteria by which candidate tools will be judged, and taking the experience of other people who have used the tools under consideration.

Here are solution strategies for this challenge:

- Take time to define the tool requirements in terms of technology, process, applications, people skills, and organization.
- Involve potential users in the definition of tool requirements and evaluation criteria.
- Build an evaluation scorecard to compare each tool’s performance against a common set of criteria. Rank the criteria in terms of relative importance to the organization.
- Perform a proof of concept (POC) as opposed to an evaluation. In a POC, the vendor often sends their technical team to your site to automate tests using your applications in your environment. Usually, a POC takes about one day to perform. The planning of the POC should be based on the evaluation scorecard. Testers should identify and define the most critical and most common tests they currently perform manually. These tests are often the ones that consume the most time and are the ones that offer the highest payback in test automation.

Summary

These 10 challenges are certainly not the only ones that are seen in test automation, but they are very common and have been the cause for many test automation project failures.

Successful software test automation is possible if fundamental issues are addressed and managed. Success depends on multiple factors that require the coordination of efforts between various groups in an organization. Automated software testing is truly a different way of testing and requires adjustments to current test methods and organizational structures. However, the payback from test automation can far outweigh the costs.

Additional Reading


About the Author

Randall W. Rice is a leading author, speaker, and consultant in the field of software testing and software quality. Rice, a certified quality analyst and certified software test engineer, has worked with organizations worldwide to improve the quality of their information systems and automate their testing processes. Rice has more than 25 years experience building and testing mission-critical projects in a variety of environments, including defense and private sector projects.

Rice Consulting Services, Inc.
PO. Box 891284
Oklahoma City, OK 73189
Phone: (405) 793-7449
Fax: (405) 793-7454
E-mail: rrice@riceconsulting.com
The term assurance has been used for decades in trusted system development to express the notion of confidence in the strength of a specific system or system of systems. The unsolved problem that security engineers must struggle with is the adoption of measures or metrics that can reliably depict the assurance associated with a specific hardware and software architecture. This article reports on a recent attempt to focus needs in this area and suggests various categories of information assurance metrics that may be helpful to an organization that is deciding which set is useful for a specific application.

... while we often claim to have metrics that prove or indicate assurance levels, we do not seem to be able to prove that correctness, maintainability, reliability, and other such nonfunctional system requirements are in the software we build.

- It is easier to attack a system today (an assurance issue) than it was years ago. This trend is likely to continue as attack tools are further automated, shared, and explored on a global basis.
- The workshop attempted to address these issues and others. Although many specific techniques and suggestions were proffered to the group, it was apparent to all that some combination of measures was essential, and that this combination could not generically be applied across all interest domains. Similarly, it was clear that the measures or metrics adopted by an organization to determine assurance need to be frequently revisited and re-validated.
- Attempts to apply a single rating to a system have been tried in the past and have failed [1, 2]. The workshop organizers also agreed that the problem domain might be best viewed using a non-disjoint partitioning into technical, organizational, and operational categories.

Definitions agreed upon by the conference organizers in the technical category were measures/metrics that are used to describe and/or compare technical objects (e.g., algorithms, products, or designs). Organizational measures might be used with respect to processes and programs. Operational measures are thought to describe as is systems, operating practices, and specific environments.

An interesting characterization of information security metrics came from Deb Bodeau of The Mitre Corporation [3] who pointed out that a proper view of these metrics might be a cross product involving what needs to be measured, why you need to measure it, and for whom you are measuring. Her characterization of this view in Figure 1 is enlightening.

Another interesting observation made by several attendees was that the desired purpose for such measures and metrics seemed to vary between the government and commercial sectors. Government applications seem much more likely to use metrics and measures for upward reporting. Answering such questions as “What is our current assurance posture?” “How are we doing this month compared with last?” and “Are we compliant with applicable regulations and directives?” seemed to be a driver for the metrics needed by government.

The representatives at the workshop from the commercial world seemed less interested in these questions and more inclined to look for answers to the ques-
that would be considered subjective and/or useul on their own. Many more measures with other measures or metrics in a partic-
ular context, and were generally not very useful on their own. Many more measures that would be considered subjective and/or qualitative appeared more useful.

Examples of more useful measures might include adversary work factor – a form of penetration testing. An excellent discussion of this topic is found in Schuedel and Wood [4]. Although penetra-
tion techniques are not truly repeatable and consistent, the workshop attendees agreed that their results were meaningful and useful. Risk assessments, in their various forms, were also found to be useful measures of assurance. Such assessments are accomplished in a variety of ways, but tend to focus attention in the proper area and give a good indication of how one is post-
tured to withstand attacks on a system.

Information Assurance (IA) metrics are essential for measuring the goodness of IA, and we believe that overall useful IA met-
rics are possible. There is general agree-
ment that no single system metric or any one perfect set of IA metrics applies across all systems. Which set will be most useful for an organization largely depends on its IA goals; its technical, organizational, and operational needs; and the resources that it can make available.

In order to help an organization inves-
tigate options for IA metrics, it is useful to look at the different categories of IA met-
rics in general. These categories are described as follows:3

Objective/Subjective
Objective IA metrics (e.g., mean annual downtime for a system) are more desirable than subjective IA metrics (e.g., amount of training a user needs to have to securely use the system). Since subjectivity is inher-
ent in IA, subjective IA metrics are more available.

Quantitative/Qualitative
Quantitative IA metrics (e.g., number of failed login attempts) are more preferable than qualitative IA metrics (e.g., the

Figure 1: Characterization of Information Security Metrics (Bodeau)


Static/Dynamic
Dynamic IA metrics evolve with time, static metrics do not. An example of static IA metrics can be the percentage of staff who received annual security refresher training [3]. This metric can degrade in value if the content of the course does not change over time. An example of dynamic IA metrics can be the percent age of staff who received training on the current version of the soft-
ware package they use. Most metrics used in penetration testing are dynamic. Dynamic IA metrics are more useful than static because best practices change over time with technology. There is always need to adapt metrics in compliance with best prac-
tices [6].

Absolute/Relative
Absolute metrics do not depend on any other measures, and these either do or do not exist [3]. For example, the number of systems administrator, networking, and security-certified security engineers in an organization is an absolute metric. Relative metrics are only meaningful in context. For example, the number of vulnerabilities in a system cannot assess the system’s IA posture alone. The type and strength of vulner-
abilities are also important in this context for making any decision about the system’s IA posture. The majority of IA metrics are relative, and so they would not be good for use as a single-system metric.

Direct/Indirect
Direct IA metrics can be generated from observing the property that they measure. For example, the number of invalid packets rejected by a firewall over a certain period of time. Indirect IA metrics are derived by evaluation (e.g., ISO Standard 15408 The Common Criteria) and/or assessment (e.g., risk assessment). Although preferred, sometimes it is not possible to measure directly.

In these cases, indirect measures are useful.

IA is a triad of cooperation between the technology that provides assurance, the processes that leverage that technology, and the people who apply and make the techn-
ology work [7]. IA metrics should be all encompassing – the product, the process, and the people, because processes build products that people use. If we want to be assured that proper information protection is in place, we need to know what it is that we wish to protect, that we have the right product for protection, that the product was built correctly, and that the right people are using it properly.

Summary
The workshop was successful in focusing attention on the area of metrics or measures for systems that have security or assurance as a requirement. It was not successful in getting agreement on a set of measures to be used, or even finding consensus in any particular approach. Nonetheless, several themes emerged from this workshop that may be useful. These are reported below, as taken from the draft proceedings of the workshop at the time of this writing.

• There will be no successful single measure or metric that can quantify the assurance present in a system. Multiple measures will most certainly be needed, and they will need to be refreshed frequently.

• Software and systems engineering are very much related to this problem: The quality of the software delivered, the architectures and designs chosen, the tools used to build systems, the specified requirements, and more are all related to assurance.

• Penetration testing is, today, a valid measurement method. It is imperfect and to some extent non-repeatable, but nonetheless, it is used in both govern-
ment and the commercial sectors. Several other testing measures are valu-
able: They include level of effort, num-
bers of vulnerabilities found (or not

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There are differences between the government and the commercial sectors. One is policy driven - the other is profit driven. Defense in depth and breadth is important. Knowing how to measure this defense is also important and a valid research area. There was no agreement on how to accomplish this measurement.

Attempts to quantify and obtain a partial ordering of the security attributes of systems in the past have not been successful to a large degree (e.g., the Trusted Computer Systems Evaluation Criteria and the Common Criteria [1, 2]).

Processes, procedures, tools, and people all interact to produce assurance in systems. Measures that incorporate all of these are important. We believe Bodeau has characterized this very well in Figure 1 (see page 31).

References
2. ISO Standard 15408. The Common Criteria

Notes
1. This work is partially sponsored by the National Science Foundation Grants CCR-0085749 and CCR-9988524.
2. Sponsored by the MITRE Corporation and the Applied Computer Security Associates.
3. The categories outlined here are from research at Mississippi State University’s Center for Computer Security Research, <www.cs.msstate.edu/~security>, in a larger effort to create a taxonomy for information assurance metrics and measures. This work can be shared by contacting the authors of this article.

About the Authors

Rayford B. Vaughn Jr., Ph.D., is professor of computer science at Mississippi State University. A retired Army Colonel, he served 26 years, including commanding the Army’s largest software development organization and creating the Pentagon Single Agency Manager organization to centrally manage all Pentagon information technology support. After retiring from the Army, he was vice president of Integration Services, Electronic Data Systems Government Systems. Dr. Vaughn has more than 40 publications and actively contributes to software engineering and information security conferences and journals. He holds a doctorate degree in computer science from Kansas State University.

Ambareen Siraj is a graduate student in the Computer Science Department at Mississippi State University and a member of the Computer Security Research Center. She is working toward a doctorate degree under the direction of Dr. Rayford B. Vaughn Jr. Her research combines the use of artificial intelligence techniques in the creation of a network-based decision engine designed to fuse and analyze information from multiple intrusion detection sensors. She also has a strong interest in the area of measuring the trustworthiness of systems and in the use of metrics and measures to do so. She has written several papers on her work and continues to be active in that endeavor.

David A. Dampier, Ph.D., served over 20 years in the U.S. Army, the last 12 as a software engineer and automation officer. In that capacity, Dr. Dampier conducted research in software prototyping and software evolution at the Army Research Laboratory, and he taught software and information engineering at the National Defense University. In February 2000, he left the Army to join the computer science department at Mississippi State University where he teaches software engineering and computer science. Dr. Dampier’s research interests are in formal methods for software engineering and software evolution, software process automation, and computer forensics.
Defeating the Forces of Nature: Two Workshops on Spiral Development

Dr. Wilfred J. Hansen
Software Engineering Institute

Spiral Development (SD) and Evolutionary Acquisition (EA) are key strategies for Department of Defense acquisition. Two workshops explored these techniques and recommended a number of steps to ensure widespread enjoyment of the advantages they have shown in individual projects. These workshops and their findings are summarized in a recent article, which describes how SD and EA can help defeat the “forces of nature” that deter projects from being on time, within budget, and high quality. CrossTalk was not able to publish the article on these workshops; however, it can be viewed at <http://www.sei.cmu.edu/ds/spiral2000/DefeatingTheForces.html>.

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www.agilemodeling.com
The Agile Modeling site was established to develop and promote the agile modeling (AM) methodology. It contains sections that explain AM: its goals, scope, and an overview of the values, principles, and practices of AM.
A rigorous three-year development process, the Institute of Electrical and Electronics Engineers (IEEE) Computer Society will offer its new Certified Software Development Professional (CSDP) examination twice in 2002: Apr. 15-June 30 and Oct. 5-26. The new CSDP credential is intended for mid-level professionals. The 3.5-hour examination covers topics such as software design, software requirements, and software testing. Candidates are required to have a baccalaureate or equivalent university degree and a minimum of 9,000 hours of experience in at least six of 11 knowledge areas. The CSDP is designed to elevate educational standards and recognize those who demonstrate knowledge essential to the practice of software engineering.

The certification examination is the first in a series to be offered under the society’s “Doing Software Right” initiative. The IEEE Computer Society developed the CSDP exam in conjunction with the Chauncey Group International, a leading certification test consultant and subsidiary of the Educational Testing Service. The exam will be offered at more than 300 testing centers in the United States and Canada, as well as in select cities in Brazil, China, Hungary, India, Ireland, Japan, and Russia.

The Computer Society has also published a new two-volume resource guide for the CSDP program, an updated and expanded version of the best-selling CS Press tutorial, Software Engineering. Further information about the CSDP examination and the CSDP preparation program is found at <http://computer.org/certification>.

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**LETTERS TO THE EDITOR**

**Dear CrossTalk Editor:**

Don Reifer states in his article [CrossTalk, Mar. 2002] “Let the Numbers Do the Talking” that he is getting tired of being misquoted. So am I. In my CrossTalk article,1 I did not state or imply that an uncalibrated software cost model would outperform a calibrated model. All estimating models must be calibrated and validated. The point I raised is that when a user recalibrates an instantiation of a cost model, the instantiation must be revalidated as a new model. The models no longer have the same characteristics.

For example, REVIC (a recalibration of COCOMO) and COCOMO are not the same estimating model. Because of the differences between the original and recalibrated models, one cannot compare estimates made by COCOMO and REVIC.

Whether a cost model is calibrated or not, when they are put in the hands of untrained, inexperienced estimators, you still get really poor estimates.

Dr. Randall W. Jensen
President, Software Engineering, Inc.
E-mail: seisage@aol.com

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**Dear CrossTalk Editor:**

Since my article “Let the Numbers Do the Talking” was published in the March 2002 CrossTalk, two questions relative to Table 2 and Table 3 keep popping up in e-mails sent to me. I hope the following clarifications will resolve the issues for everyone interested.

Table 2 - The cost per staff month of $12,000 reflects burdened labor cost exclusive of G&A and profit for typical inexperienced labor mixes across both military and commercial domains. This is the internal cost of a person. It is not the price charged when the services of a person are sold to a third party (another division, government customer, etc.).

The price per person-month varies greatly by industry because of skill mix, experience, and business practices. For example, the average price per person-month for a regular software engineer within the aerospace industry ranges from $21,000 to $25,000/person-month. This price reflects a more experienced staff mix than what is normal in the commercial world and additional markups to reflect the high costs of doing business with the government.

In contrast, the internal price that organizations within the telecommunications industry charge other parts of the same firm for services can be as low as a base cost of $12,000 to $15,000/person-month. When the labor mix is young, profit doesn’t enter into the calculation, and only a very small markup is charged for doing business with a sister organization.

Table 3 - SRR in this table refers to Software Requirements Review, not Systems Requirements Review.

Donald J. Reifer
Reifer Consultants, Inc.
E-mail: dreifer@ieee.org

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**First-of-Its-Kind Software Development Certification Exam Offered**

After a rigorous three-year development process, the Institute of Electrical and Electronics Engineers (IEEE) Computer Society will offer its new Certified Software Development Professional (CSDP) examination twice in 2002: Apr. 15-June 30 and Oct. 5-26. The new CSDP credential is intended for mid-level professionals. The 3.5-hour examination covers topics such as software design, software requirements, and software testing. Candidates are required to have a baccalaureate or equivalent university degree and a minimum of 9,000 hours of experience in at least six of 11 knowledge areas. The CSDP is designed to elevate educational standards and recognize those who demonstrate knowledge essential to the practice of software engineering.

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When you travel, you already know you automatically add a “com” after a bookstore, you pick up an introduction, you include your e-mail address.

Week of the Geek

The other day, I was saving some data to my favorite backup media— which happens to be a 128 Meg SmartMedia card. The card is small and has the capacity of 88.8888… (Oh heck—let’s round it off to 90) floppies. I carry the card in my sunglass case. A friend saw me pulling the card out of my glass case and called me a “geek.”

Me? A geek? Probably. I’m not ashamed of it. In fact, I think I’m a bit proud of the title. But do I look like a geek? In fact, how do you tell who the geeks are? There used to be certain indicators that you were a geek. The best sign used to be black plastic eyeglass frames (with white tape holding them together at the nosepiece). Now, thanks to laser eye surgery, geeks don’t need to wear them anymore. Also—thanks to retro fashions—lots of people who are not geeks are wearing black plastic frames, which happen to be in fashion. (Sure, now that I don’t wear them anymore!)

Another sign used to be a plastic pocket protector full of pens and pencils. Nowadays, I own a single all-in-one writing instrument that has a palm stylus, black pen, red pen, and pencil. No pocket protector needed. And in the very old days, a dangling slide rule at the belt was also a prerequisite of geekhood. Nowadays, slide rules dangle in the Smithsonian.

What we need today are contemporary indicators of being a geek. After some thought, I submit the following list as reasonable indicators of geekiness:

- You have 50 people in your online address book, but only three have real addresses.
- You send more e-cards than real ones.
- Some of your best friends are people you have never actually met in person.
- When in a bookstore, you pick up an “X for Dummies” book, you read a bit, laugh, and say, “Nobody could really be THAT dumb.”
- You automatically add a “com” after a period when typing.
- When you introduce yourself, you include your e-mail address.
- You attend a conference and automatically look for a seat near an outlet, so you can plug in your computer.
- When you travel, you already know where outlets are located in the airline gate areas.
- A good hotel is defined as one where you can get a 52K bps connection (bonus points if you know which hotels in advance).
- You have e-mail addresses for different facets of your personality. For example, david.cook@hill.af.mil for work, and brainy_student@someISP.com for home. (Only the first one is actually mine.)
- You frequently wish life had an undo or back key.
- When your significant other says you need to communicate better, you think that means you can get DSL.
- By looking at the control panel applications, you unconsciously determine whether the computer is running 95, 98, ME, 2000, or XP.
- You go to conferences where well-dressed guys wear suits or sports coats with very short high-water pants and running or tennis shoes. Extra points for white socks. Double points for white socks with black or navy pants.
- You have gotten up in the middle of the night to check the status of either a big download or a disk defrag.
- You wonder whether you can daisy chain USB port replicators to give you more than four USB connections per computer port. Extra points if you really need more than four USB connections per computer port.

CrossTalk is “The Year of the Scientist and Engineer.” If you will e-mail me your geek stories and indicators, I will compile them and have an appropriate BackTalk column on a palm computer while attending a computer conference. Mind you, I’ll just call it good time management!

Do you know other signs of being a geek? Well, the theme of the December 2002 issue of CrossTalk is “The Year of the Scientist and Engineer.” If you will e-mail me your geek stories and indicators, I will compile them and have an appropriate BackTalk column for the December issue. Send them to me at david.cook@hill.af.mil. We’ll have a “Top 10” geek indicators list.

To conclude, if December 2002 marks the “Year of the Scientist and Engineer,” I hereby proclaim the Software Technology Conference 2002 to be the “Week of the Geek.” Hope I see you there.

By the way, one sign of being a geek might be that you wrote your BackTalk column on a palm computer while attending a computer conference. Mind you, I’ll just call it good time management!

– David A. Cook, Geek Software Technology Support Center

P.S. By the way, three trips to Fry’s during a four-day conference is not abnormal. And that was not the only reason I decided to attend.
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Software Technology Support Center
QO-ALC/TISE • Building 100 • 7278 4th Street • Hill AFB, UT 84056-5205
(801) 775-5555 • DSN 775-5555 • FAX (801) 777-8069 • DSN 777-8069 • www.stsc.hill.af.mil